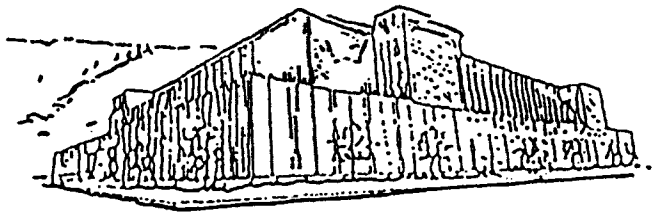
1997

Origin and spread of syphilis

Jun Hong
The University of Montana



Maureen and Mike
MANSFIELD LIBRARY

The University of **MONTANA**

*** Please check "Yes" or "No" and provide signature ***

Yes, I grant permission X
No, I do not grant permission ____

Author's Signature Jun Hong

Date 05/05/97

The Origin and Spread of Syphilis

BY

Jun Hong

B.M., Tianjin Medical University, P. R. China. 1992

Presented in partial fulfillment of the

requirement of the degree of

Master of Arts

University of Montana

1997

Approved by:

Randall R Hunter

Chair, Board of Examiners

Dean, Graduate School

5-5-97

Date

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 - 1346

ABSTRACT

Hong, Jun, M. A., Spring, 1997 Anthropology

The Origin and Spread of Syphilis(89 pp.)

Director: Randall R. Skelton RS

The purpose of this study is to investigate the origin of syphilis, a type of treponematosis, which is a family of diseases including syphilis, bejel, yaws, and pinta. While syphilis is venereal disease, the others are nonvenereal. Currently, three hypotheses are available to explain the origin and distribution of syphilis. The Columbian hypothesis states that Columbus's crew acquired syphilis from Native Americans and carried it back to Europe in 1493 A. D.. On the contrary, the supporters of the pre-Columbian hypothesis assert that syphilis was present in Europe long before Columbus's voyage and was transferred to the New World by Columbus's men. The unitarian theory argues that syphilis, bejel, yaws, and pinta are not separate diseases caused by different organisms. Instead, they represent syndromes caused by slightly different strains of one organism.

An examination of precontact skeletal remains yields syphilitic skeletal remains only in the Old World. Therefore, the pre-Columbian hypothesis is valid and Columbian hypothesis is invalid. Clinical, morphological, biochemical, immunological, and histological evidence suggests that the treponematoses are the same disease with no qualitative difference, although they are clinically distinguishable. In fact, syphilis emerged from other types of treponemal infections in the Old World when the physical and social environments selected for it. Then, syphilis was transferred from the Old World to the New World by European immigrants, although nonvenereal treponematoses existed in the New World before Columbus's voyage.

Generally speaking, the Unitarian theory explains the origin of syphilis in the Old World and pre-Columbian theory illustrates the transmission of syphilis to the New World.

ACKNOWLEDGMENTS

I would like to thank my thesis chairperson, Dr. Randall R. Skelton, for his tireless patience, gentle prodding, and pragmatic stance throughout this project. In addition, the assistance of my committee members, particularly Dr. William Prentiss and Dr. Fred W. Allendorf, was invaluable.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

The primary goal to be accomplished through the presentation of this research is an increased understanding of the origin of syphilis. This topic has been a controversial problem for hundreds of years and many papers and books have been written on this subject. Three hypotheses, including the Columbian hypothesis, the pre-Columbian hypothesis, and the Unitarian hypothesis have been proposed to explain the origin and subsequent spread of syphilis all over the world (Baker and Armelagos 1988). The Columbian hypothesis (e.g., Baker and Armelagos 1988; Bloch 1908; Bruhl 1890; Capper 1925; Crosby 1969; Dennie 1962; Guerra 1978; Harrison 1959; Pusey 1933; Shattuck 1938; Stewart and Spoehr 1952, 1967; Williams 1927; Zinsser 1935) states that Columbus's crew acquired syphilis, a totally new disease for Europeans and other Old World peoples, from Native Americans, carrying it back to Europe in 1493. The proponents (e.g., Brothwell 1970; Cockburn 1961,

1963; Hackett 1963, 1967; Holcomb 1934, 1935, 1941; Hyde 1891; Willcox 1973) of the pre-Columbian hypothesis assert that syphilis was present in Europe long before Columbus's voyage and was transferred to the New World by Columbus's men.

Syphilis, bejel, yaws, and pinta are four similar treponemal infections, but only syphilis is venereal. The Unitarian theory argues that syphilis, bejel, yaws, and pinta are not separate diseases caused by different organisms. Instead, they represent syndromes caused by slightly different strains of one organism (Butler 1936; Hamlin 1939; Hollander 1981; Hudson 1958, 1963a, 1965b; Weisman 1966). Therefore, the origin of syphilis is relating to the other treponemal infections.

The study of the development of syphilis will contribute to our anthropological knowledge. As we know, anthropology is the study of the physical and cultural development of the human species from prehistoric through modern times (Holmes and Parris 1981). The evolution of human culture and biology was influenced by many factors, and disease was one of them. The study of the relationship between culture, diseases, and human biology in ancient times offers a unique opportunity for anthropologists to learn more about human adaptability.

Infectious diseases, as a cause of mortality and morbidity, has the potential to be a strong selective force in the evolutionary process. These diseases have influenced not

only the biology of individuals, but society, culture, and even the history of people. In the face of these microscopic invaders, human populations have been forced to adapt to infectious agents on the level of both genes and culture (Inhorn and Brown 1990). On the other hand, the evolution of human culture and biology also affects the evolution of human pathogens. It seems that anthropologists have been more interested in the first aspect of the interaction rather than the second aspect. However, an examination of both aspects will give us a complete picture of this interaction. In this paper, the evolution of syphilis will be discussed.

Generally speaking, syphilis may have been transferred from the Old World to the New World or from the New World to the Old World through Columbus's voyage and it is also possible that Columbus's voyage had nothing to do with syphilis that developed in both worlds separately before 1493 A.D.. An examination of precontract evidence of syphilis will be critical for us in evaluating these possibilities. Fortunately, syphilis, yaws, and bejel leave characteristic lesions on skeletal remains and we can recognize syphilis by typical specimens. The discovery of precontract syphilitic bones in the Old World would disprove the Columbian hypothesis. On the other hand, the absence of syphilitic skeletal remains before 1493 A.D. in the New World would validate the Pre-Columbian hypothesis. While the pre-Columbian

hypothesis and Columbian hypothesis are mutually exclusive, the Unitarian hypothesis is not mutually exclusive with them. Microbiological, clinical, evolutionary evidence is examined to clarify whether bejel, yaws, syphilis, and pinta are one disease, or whether quantitative differences exist between them. The comparison of the morphology, immunology, histology, and DNA of treponemal pathogens will demonstrate whether they are the same kind of organism and show whether treponematoses are syndromes of one disease. A discussion of the origin of the clinical differences among the treponematoses will show they are the expression of one disease under different conditions.

Since the emergence of syphilis is the result of natural selection, an evolutionary model is indispensable for our understanding of the origin of syphilis. I will present an evolutionary theory that suggests that syphilis appeared when the environment selected for it, and it could not emerge and survive without a change in environment, such as improved hygienic conditions. According to this model, treponematoses stayed in nonvenereal forms in the New World because the social and physical environments in the New World did not favor the evolution of syphilis, but in the Old World they did.

The Unitarian hypothesis will be used to explain why syphilis originated in the Old World instead of the New World,

and the pre-Columbian hypothesis to explain the transmission of syphilis from the Old World to the New World.

CHAPTER 2

LITERATURE REVIEW

This chapter is a review of literature relating to the development of Columbian hypothesis, pre-Columbian hypothesis, and Unitarian hypothesis.

The Columbian Hypothesis

Gonzalo Fernandez de Oviedo was probably the first person who argued for the Columbian hypothesis. In 1526, he published a book titled De la Natural Historia de Las Indias (The Summary of the Natural History of the Indies). In the chapter on lignum vitae, he wrote that the principle virtue of this wood was to cure syphilis which came from the Indians (Naranjo 1995). Nine years later, Oviedo published another work, Historia General Natural de Las Indias, islas y Tierra Firme del Mar Oceano (General and Natural History of Indies, Islands and Mainland of the Ocean Sea) and argued for the Columbian hypothesis (Naranjo 1995). The major impetus for regarding the New World as the cradle of syphilis was the discovery of

lignum vitae, a remedy, in New World, because of the ancient maxim that "wherever God sends punishment or disease, there he also sends the cure" (Steinbock 1976).

Bruhl (1890) examined many primary historical records and he concluded that syphilis existed in the New World at the time of its discovery. After reviewing documentary materials relating to Old World medical literature, Bloch (1908) proposed that there was not a particle of evidence to show that the syphilis existed in Europe before 1493. Bloch (1908) believed that the presence of syphilis would have led to its widespread prevalence had it existed in the Old World. He further argued that no skeletal evidence of syphilis was found in the Old World. Pusey (1933) attributed the origin of the European infection of syphilis to Columbus. Williams (1932) examined and made notes on more than 500 known modern and ancient syphilitic skulls. After a critical review of published material and his own observation he said": It seems to me that the evidence from bones points clearly to the conclusion that the Indians were afflicted with syphilis in a number of parts of America before the arrival of white men . . . Similar proof from the eastern hemisphere may yet appear, but it has not been produced up to this time."

A bacteriologist, Zinsser (1935), argued in his book Rats, Lice, and History that there is little doubt that when syphilis first appeared in epidemic form, at the beginning of

the sixteenth century, it was a far more virulent, acute, and fatal condition than it is now. He went on to discuss that the disease was introduced into Europe by Columbus's sailors returning from Hispaniola.

Shattuck (1938) provided clinical evidence and discussed the connotations of incomplete immunity built up by prolonged exposure. He wrote that the modern Indians of Mexico and Central America had a low incidence of syphilis, an almost complete absence of internal organ involvement, and a high degree of latency. Therefore, syphilis had been the New World long before Columbus's voyage.

A modified version of the Columbian theory suggests that syphilis existed in the Old World before Columbus, but the new epidemic of 1493 represents the introduction of a more virulent strain. Stewart and Spoehr (1952) suggested that Europe and America each had its own variety of syphilis and therefore may have exchanged treponemata for which the recipient populations lacked immunity. Harrison (1959) did not agree with the theory that syphilis experienced a mutation in Europe around 1493 and that it was milder before that mutation. He "believed that the mutation occurred in America" (1959:2).

Dennie (1962) pointed out that the introduction of a totally new disease, to which European people had never been exposed and had no immunity to, would explain its rapid spread

to every part of Europe. Crosby (1969) proposed that treponematosis, originally a single disease, evolved into several related but distinct maladies as man spread throughout the world and that syphilis was the variant developed in the New World where it was introduced to Europe with the return of Columbus.

Capper (1925), a physician, believed that "the origin of syphilis in America could perhaps be traced by way of the sea from Japan or from any other part of East Asia and syphilis was imported into Europe from the New World by the crew of Columbus in 1493" (519). In addition, he pointed out that "The epidemic that was raging in Europe following the return of Columbus was due either to some diseases or diseases other than syphilis or syphilis plus the other disease, syphilis however playing a minor role in the ravages resulting from the epidemic"(Capper 1925:519).

Guerra (1978) proposed the theory that "there were in America the four types of human pathogenic treponematoses, pinta, yaws, venereal syphilis, and probably endemic syphilis (bejel), in Europe at the same time venereal syphilis and endemic syphilis. The discovery of America brought the spread to Europe of American bubas, or yaws, a new rural and tropical treponematosis; after several generations, yaws adapted itself to the temperate urban environment of venereal syphilis, changing the original violent epidemiological character, as

corresponding to a new mutant of treponematosis" (1978:57).

The Pre-Columbian Hypothesis

The proponents (e.g., Brothwell 1970; Cockburn 1961, 1963; Hackett 1963, 1967; Holcomb 1934, 1935, 1941; Hyde 1891; Willcox 1973) of the pre-Columbian hypothesis assert that syphilis was present in Europe long before Columbus's voyage and was transferred to the New World by Columbus's men. In 1891, Hyde (1891) stated that the ancient medical documents of China, Indian, Greece, and Italy contain unmistakable proof that genital lesions were known to occur from sexual contact long before Columbus's voyage. Holcomb (1935) cited early descriptive medical reports of a disease regarded by the early writers as leprosy and argued that many of purposed cases of leprosy were clearly syphilis. This is supported by the description of the appearance and the venereal mode of transmission.

Cockburn (1963) believed that the ancestor of treponeme was a free-living organism in the soil or water. The development of symbiosis between the free-living forms and large animals took place many millions of years ago. Humans may have inherited treponeme from their remote primate ancestors or gotten it from some other animals more recently. The original settlers of the New World were already infected when they first crossed the Bering land bridge and

treponematosis was not carried by Columbus from one continent to infect another. By about 1,000 A.D., treponeme would have existed either as a commensal or parasite on all continents of the world. As the numbers of people in the Old World rose, more acute infections would be selected for. When the hygiene was bad and favored skin-to-skin transmission, yaws developed. Syphilis emerged when hygienic environments prevailed and the chance for skin-to-skin transmission was rare. Pinta was the result of geographic isolation.

Hackett (1963) wrote about the evolution of treponemal infections. He thought pinta may have been the earliest human treponematosis. It may have been subsequently isolated in the Americas when the Bering Strait was flooded. Environmental conditions might have favored treponeme mutants leading to yaws about 10,000 B.C. in the African and Asian continents. About 7,000 B.C., bejel developed from yaws, and gave rise to venereal syphilis about 3,000 B.C., in southwest Asia, as big cities developed there. Syphilis could have existed in some mild form in Europe for centuries and a further mutation may have resulted in a more severe syphilis in Europe toward the end of the 15th century A.D.. With European exploration, syphilis was carried throughout the world.

Brothwell (1970) proposed that ancient skeletons suggest that syphilis originated in Asia more than 2,000 years ago. Then, It spread across the Pacific to the New World and

westward to Europe with the expansion of the Arabian empire.

Willcox (1973) summarized the earlier theories of Hackett (1963) and Hudson (1958, 1964, 1965b), and postulated that the treponematoses originally arose in man as commensal saprophytes. "As a result of mutation and natural selection of the varieties best suited for transmission under the environmental conditions pertaining; the various treponematoses then evolved into pinta, through yaws and endemic syphilis, to venereal syphilis which has worldwide distribution today. Changes in social conditions may lead to a regression or alteration as regards the dominant treponematosis" (Willcox 1973:18). For example, he suggested that in the Old World, syphilis emerged from bejel when unhygienic habits were discarded, permitting some children to escape the childhood infection.

The Unitarian Hypothesis

Butler was one of the earliest scholars to suggest the Unitarian hypothesis. In his book, Syphilis Sive Morbus Humanus, Butler(1936) argued against the Columbian hypothesis and showed the unity of so-called "yaws" and syphilis.

Later, Hamlin (1939:48) wrote, in The Geography of Treponematosis, "The world-wide epidemiology of treponematosis, however, indicates that the diseases produced, can be regarded as geographic representatives in time and

place of homologous pathological reactions." He suggested that movements of peoples carried the infection from Africa into Asia, and then to Americas via the land bridge.

Grin (1956) considered the treponematoses to be closely related infections, and stressed the Unitarian view. He wrote articles which argued that both bejel and yaws have very similar epidemiological characteristics. "There is also considerable similarity in the clinical manifestations at various stages of yaws and endemic syphilis, with the differences that do appear being mainly due to different environmental and living conditions" (Grin 1956:959).

Hudson (1963a) advocated employing "treponematosis," instead of "treponematoses," when the disease as a whole and in all its manifestations is intended. He believed that pinta, yaws, bejel, and syphilis are just different epidemiological patterns of the same disease.

Hudson (1965b) speculated that the ancestor of T. pallidum was a saprophyte and that the parasitization of man took place in Central Africa. The first transition is from yaws to bejel, when the hunters migrated from humid Central Africa to the drier regions. Bejel and yaws were particularly suited for propagation in hunter and gatherer villages. The gradual transition from nonvenereal treponemal infection to syphilis occurred when towns and cities came into being in Mesopotamia five or six thousand years ago. In a clean and

clothed 'Urbane' society, coitus has become the only contact of sufficient intimacy to ensure the transfer of treponemes. The distinction between different forms was not based on etiology but on epidemiology. Hudson surmised that such changes might occur in a few years, a few generations, or in centuries, depending upon the speed with which environmental conditions changed. Hackett's (1965a) evolutionary scheme differs from that of Hudson in that Hackett's idea involves change from one disease to another and from one species of pathogens to another by mutation at a definite time and place. Hudson (1965a), on the other hand, would not agree that there were mutations because the treponematoses are all the same organism. "The treponemes may diverge, but they never lose their ability to regain their former state."

Weisman (1966) also believed "Treponematosis was and is both in Europe and the New World. Columbus and Erickson and the other early travelers had little to do with the organism itself" (1966:299). He used some pre-Columbian Sculptures as evidences, because "the ancient pre-Columbian sculptures of the Western Hemisphere depicted pathology and disease with startling, sometimes shocking, realism" (1966:291).

Hollander (1981) subscribed to Hudson's hypothesis and stressed the importance of environmental temperature. Based on observations in experimentally infected laboratory animals, the geographic distribution of treponemal syndromes, and the

distribution of lesions in the respective clinical syndromes, he concluded the several treponemal diseases are logically explainable as different infection patterns of a single pathogenic organism under different environmental temperatures.

Recently, Baker and Armelagos (1988:703) argued "A review of the literature strongly suggests a New World origin of the treponemal infections. Whereas the evidence for pre-Columbian treponematosis in the Old World is documentary and equivocal, there is a vast array of skeletal evidence indicating the presence of a nonvenereal form of treponemal infection in the Americas prior to Columbus's arrival." Their position is that nonvenereal treponemal infection is a New World Disease that spread to the Old World and became a venereal disease that was selected for by the environments in Europe.

Like Baker and Armelagos, Bogdan and Weaver (1992) proposed that Columbus and his crew carried endemic treponematosis back to Europe. Because of the differences in the quality and style of life, nonvenereal treponematosis changed into syphilis.

CHAPTER 3

METHODS

In this chapter, I will introduce the methods used in this paper, give a description of treponemal diseases, offer a method for the diagnosis of treponemal infections on bones, discuss the differential diagnosis of syphilitic skeletal remains, and express my opinion about historical documents.

For this analysis, I will use the diagnostic criteria discussed in the following section to review and examine paleopathological evidence from both the Old and New Worlds. "In paleopathology two basic data are required: accurate dating and accurate diagnosis" (Hackett 1983:106). If the above two basic data are definite, reliable conclusions regarding the prehistoric distribution of treponematosis may be drawn from skeletal evidence. Therefore, a review of Old and New World skeletal remains of pre-Columbian times is necessary.

An understanding of the morphology, biochemistry, and

histology of treponema is critical for determining whether the treponematoses are one disease or not.

Because syphilis, yaws, bejel, and pinta can be clinically distinguished, a discussion of the difference between them and the origin of difference is also necessary.

Since infectious disease involves the relationship between organisms, namely, pathogens and hosts, the general rules of the biological world may be applied to it. A number of scholars have described the coevolution of human culture and infectious disease, basing their argument on evolutionary theories (e.g., Armelagos and Dewey 1970; Cockburn 1971; Dubos 1965, 1968; Ewald 1994; Hackett 1967; Hudson 1965a; Mckeown 1988; Polgar 1964). These rules may be applied profitably to the origin of syphilis.

Description and Diagnosis of the Treponemal Diseases

There are four treponemal diseases: pinta, yaws, bejel, and syphilis (Steinbock 1976). Pinta exists only in remote rural areas of arid inland regions of the New World (Chulay 1995). Transmission occurs only through contact of broken skin with infectious lesions and most patients acquire the infection during childhood (Engelkens et al. 1991). It is unique among the treponematoses in having only skin manifestations. Primary lesion may persist for several years before healing with residual hypopigmentation (Chulay 1995).

Bejel, which is prevalent in warm arid climates, is a chronic childhood infection of skin, bone, and cartilage (Koff and Rosen 1993). It is believed to be transmitted from child to child by close skin contact and sharing of drinking vessels (Koff and Rosen 1993). A primary lesion is rare in bejel compared with yaws and pinta (Grin 1956). Secondary lesions consist of oropharyngeal mucous patches, split papules at the corners of the mouth, condylomata lata, periostitis, and regional lymphadenophy (Koff and Rosen 1993). Late manifestations include gummatous lesions of the skin, nasopharynx, and bones. Cardiovascular lesions occur with some frequency, but involvement of the central nervous system is rare (Chulay 1995).

Yaws exists among rural populations in warm humid tropical areas (Koff and Rosen 1993). Transmission occurs when traumatized skin comes in contact with infectious exudate from active yaw lesions. Yaws is mostly contracted in childhood and children younger than 15 years of age are most commonly affected (Chulay 1995). The primary infection, mother yaws, is usually acquired before puberty. Early lesions appear on the extremities, especially the legs. Disseminated cutaneous lesions, palmoplantar lesions, osteitis, and periostitis can occur during the secondary stage. The late stage of yaws is characterized by cutaneous plagues, nodules, and ulcers, hyperkeratoses of the palms and soles, and gummatous lesions

involving the skull, sternum, tibia, or other bones. Cardiovascular and neurologic manifestations are rare (Chulay 1995).

Syphilis has no climatic restrictions (Steinbock 1976) and can be acquired by sexual contact and passage through the placenta (Tramont 1995). Clinically, it can be divided into five stages including incubating, primary, secondary, latent, and late syphilis. The incubating stage varies from 3 to 90 days. The primary stage refers to the development of the primary lesion, chancre, which occur at the site of inoculation. It usually heals spontaneously in 2 to 12 weeks. The manifestations of the secondary stage are widespread and protean. The most commonly recognized lesions, such as maculopapular, papular, and pustular lesions, occur in the skin. After the secondary stage, the patient enters a latent period. Late syphilis refers to the lesions involve the vaso vasorum of the aorta and the arteries of the CNS, and to the gummas, which are agranumatous lesions that can occur anywhere in the body (Tramont 1995).

Treponemal infections occur in four clinically different diseases including syphilis, bejel, yaws, and pinta, but only the first three may affect the skeleton (Ortner and Putschar 1985). The early publications about syphilis on dry bones were written by Virchow (1858, 1896) and Jones (1876). Later publications relating to the diagnostic criteria of syphilitic

lesions on dry bones are plentiful(e.g., Hackett 1976, 1983; Hooton 1930; Hyde 1891; Jaffe 1972; Kerley and Bass 1967; Orton 1905; Ortner and Putschar 1985; Putschar 1966; Steinbock 1976; Williams 1932).

Usually, syphilitic bone lesions occur during the tertiary stage (Steinbock 1976). The tibia, the bones surrounding the nasal cavity, and the cranial vault are places that are frequently involved. Because syphilis is a blood-borne infection, the metaphyses of the long bones, which are well vascularized, are usually the initial places where periostitis begins. It is characterized by the formation of subperiostitis bone in response to the periosteal inflammation. In many cases, the apposition results in thickening of the bone (Steinbock 1976). The localized form of periostitis may leave elevated, plaque-like exostoses on the cortex of bones (Ortner and Putschar 1985). Osteitis and osteoperiostitis are extensions of the infection from the periosteum to the bony tissues. The shafts of the long bones and the cranium may be thickened. The medullary cavities of the long bones are greatly narrowed by the cortical thickening. The subperiosteal apposition of new bone on the anterior surface of the tibia can result in saber-shin tibia. Some destruction is exhibited by pitting on the surface of the bone, which is the result of the localized inhibition of the blood supply (Steinbock 1976). "Gumma formation is the

combined result of thrombosed blood vessels restricting the blood supply to the bone and to the toxic products of treponeme degeneration . . . Most gummata begin in the metaphysis but extensive involvement of the entire marrow cavity soon results, with both proliferative and degenerative changes. All bone is destroyed in the space occupied by the gumma but the surrounding bone often becomes very sclerotic" (Steinbock 1976:123). The descriptions of long bone lesions in yaws and bejel are identical to those of syphilis, differing only in the relative frequency of various types of lesions (Ortner and Putschar 1985; Steinbock 1976). Because yaws is usually acquired in childhood, the most active lesions are seen in children (Ortner and Putschar 1985). One to five percent of a skeletal series from an endemic area may have bone lesions. The tibia is the most common bone involved, followed by the fibula, medial portion of the clavicle, femur, ulna, and bones of the hands and feet. Lesions in the hand are often found, in contrast to the infrequency of dactylitis in syphilis. The saber-shin tibia, which can be found in syphilis is a prominent feature of yaws as well. Bejel resembles yaws and also primarily infects children. The tibia is often involved resulting in saber-shin tibia (Steinbock 1976).

Williams (1932:800) stated the diagnostics of syphilis as follows: "The skull is most important: Extensive involvement of its upper surface, the so-called 'saries sicca', the 'worm-

eaten' appearance justify the diagnosis of syphilis in all reasonable probability." He (1932:784~85) examined 500 known syphilitic skulls and proposed:

> The type of skull that is most characteristic of syphilis is that produced by wide spread gummatous inflammation of the periosteum, frequently with localized gummatous nodules, the gummatous periostitis is accompanied by a certain amount of osteitis, It leads to destruction of bone and simultaneously or later there is new formation of bone at the edges of the parts affected. An unevenness or irregularity of the surface of the skull results that is peculiar and distinctive. English books sometimes speak of it as appearing "worm eaten" . . . Such scars produce jagged, linear, not rarely stellate depressions, with the most marked defect in the middle, and with smooth, rounded and elevated edges. Virchow revived the term "caries sicca," used by an earlier author, Bertrandi, for this process . . .

Syphilis frequently affects the outer surface of the calvaria and the inner surface is rarely involved. Usually, lesions begin on the frontal bone. In a considerable proportion of cases, late syphilis may involve the nasal region or hard palate (Williams 1932).

Unlike venereal syphilis, the cranial vault is rarely affected by bejel (Steinbock 1976). "A localized osteitis without extensive destruction is the only result" (Steinbock 1976:139). For bejel, the destructive nasal lesions resulting in perforation of the hard palate are not uncommon (Grin 1953). Compared with the frequency and severity of cranial syphilis, yaws is less common and less destructive (Williams 1932). The bone lesions of yaws exhibit few crater-like depressions on the frontal bone (Hackett 1951). Destruction

around the nasal cavity is a rare complication of yaws (Ortner and Putschar 1985).

Early congenital syphilis includes the skeletal lesions that appear from birth to three or four years. The osseous lesions of syphilis can be metaphysitis, periostitis, and diaphyseal osteomyelitis. When foci of osteomyelitis are present at the proximal ends of both tibiae on their medial aspects, it is called Wimberger's sign, which is highly suggestive of congenital syphilis. Later congenital syphilis occurs between five and fifteen years of age. The bone lesions of late congenital syphilis are hyperplastic osteoperiostitis and gummatous osteomyelitis (Steinbock 1976). Hyperplastic osteoperiostitis primarily involves the diaphyses of the long bones, and the tibia is frequently affected bilaterally producing the well-known saber-shin tibia (Steinbock 1976). Hutchinson's incisors and Moon's molars are typical dental stigmata. Permanent incisors with reduced occlusal dimensions, crescentic notches of the occlusal margins, and thin or defective occlusal enamel are termed Hutchinson's incisors. Hutchinson (1863) considered these features to be pathognomic of congenital syphilis. First permanent molars with crowding and infolding of the cusps and thin or defective occlusal enamel are termed Moon's molars. Mulberry, bud, dome-shaped, and Pfluger's molars are different terms for the same thing. This molar is smaller than the normal first molar (Steinbock

1976).

Several diseases show similar bone changes when compared with the treponematoses. However, differential diagnosis is possible for typical specimens. Osteomyelitis is one such disease, and "In the absence of other data, in a single dried bone it may be quite impossible to distinguish it (osteomyelitis) from syphilis by any means of diagnosis known" (Williams 1932:793~794). We now know that Osteomyelitis is more likely to affect a single bone and produce sequestra surrounded by some smooth walled sinuses. Therefore, if we have most parts of a skeleton, it should not be difficult for us to differentiate treponematoses by finding lesions on multiple bones (Bullen 1972).

Skeletal tuberculosis often proves similar to syphilis but it is essentially destructive with very little new bone formation. The spine is most commonly affected (Bullen 1972). Erdheim stressed the changes on the inner rather than the outer surface of skulls for tuberculosis (Hackett 1976). Paget's disease may produce changes in the bones indistinguishable from syphilis to the naked eye (Williams 1932). However, the marrow cavity is enlarged as the cortex expands. Microscopically, a mosaic pattern resulting form rapid and erratic remodeling can be found (Bullen 1972).

Documentary Evidence

The argument about the origin of syphilis has been going on for centuries. In the beginning, most of the hypotheses involved historical documents. Therefore, ancient medical literature and related materials were reviewed by different scholars. The most recent publications correspond to the growth of "medical history," which relied heavily on descriptions of medical matters and pictures of pathology of ancient people.

Syphilis and related diseases have been mentioned in many ancient works. By studying these ancient records, researchers can get some valuable data. However, although the study of diseases through literary sources is often insightful, textual records may include pitfalls. The causes of the mistakes can be misunderstanding, errors of transcription, and improper translation, among others. Sometimes, it is hard to translate ancient linguistic usages. "Attempts to analyze the historical course of syphilis has always encountered the difficulty of disengaging that disease from the melange of symptoms and signs comprised by ancient and medieval medical writings" (Hudson 1961:545). Through time, the accumulation of transcription errors can make the later copies quite unreliable. Even modern scholars cannot interpret the world correctly, and we are not sure whether an ancient recorder was keeping an accurate record. In ancient times, observers used their contemporary methodology to interpret the data, so their

records may be affected by their methods. Given the limitation of medical and other knowledge, their records may be unreliable. For example, in 1496, Ulcenio, a famous physician, claimed that syphilis was caused by the conjunction of Jupiter, Saturn, and Mars (Naranjo 1995). It is not hard to imagine that his theory may affect his description of the mechanism, manifestations, treatment, and diagnosis of disease. Every patient has the chance to leave skeletal remains, but not all of them can enter historical records. The availability of written language limits the patients to some societies in some historical periods. History is the victors' story, so a reader may be misled by biased records. For infectious diseases, many historians claimed their people were victims of other groups of people. In the 16th century, the French called syphilis the Neapolitian disease, whereas Neapolitans, who believed the illness had been brought by the French, called it the French disease (Naranjo 1995).

Considering the fact that historical documents have been disputed by scholars (e.g., Baker and Armelagos 1988; Bloch 1908; Bruhl 1890; Crosby 1969; Dennie 1962; Harrison 1959; Holcomb 1934, 1935, 1941; Hudson 1961, 1963b, 1964, 1972; Hyde 1891; Guerra 1978; Naranjo 1995; Weisman 1966; Williams 1927) for more than one hundred years and no positive conclusion has ever been reached, I choose not to use this source of data. Hudson (1958:6) said": by selecting the 'right' witnesses and

dates and discarding the rest, it is possible to build a case for either view, depending on the credibility of the witnesses and the credulity of the reader." Most likely, the solution to this puzzle will depend on new approaches instead of sticking to the old limited approaches, which only lead to further debate.

CHAPTER 4

RESULTS

In this chapter, I will review skeletal remains, analyze clinical manifestations and microbiology, and discuss evolutionary theories relating to the treponematoses.

Skeletal Remains from the Old World

Although the Old World skeletal evidence has been lacking, the accumulation of skeletal evidence in the Old World has been quite impressive over the last decade, compared with previously. The Old World evidence for pre-Columbian treponematosis comes primarily from Europe. Scattered sites in Britain have yielded evidence of syphilis. At Norwich, the remains of 436 undisturbed skeletons were excavated and four adults exhibited bone changes characteristic of treponemal disease. "The boundaries of the site are excellent and, most important, the cemetery was in use from the 1100s to AD 1468" (Stirland 1991:40). There are widespread postcranial changes on a young adult male (number 412) with a

fragmented skull. The lesions exhibited by number 412 strongly suggest treponemal disease."The affected bones are both distal ulnae and radii, both femora, both tibiae and fibulae, the tarsals, particularly on the left fifth metatarsal. There is a great deal of florid periosteal new bone, particularly on the tibiae and the fibulae . . . The bone appears inflated pleated and folded and these changes run up the interosseous borders, with pitting of the new bone"(Stirland 1991:40). On the left maxilla of a mature adult female (number 68), confluent clustered pits are observed; postcranially, most of the skeleton is involved. A third skeleton (number 129), exhibits an area of healed radial scars on the frontal bone. The skull of a fourth case (227) exhibits a solitary focal superficial cavitation lesion. The left clavicle, right humeri, both ulnae, right femur and both scapulae all have areas of periosteal new bone. Differential diagnosis and geographical situations suggest that these individuals may have been suffering from syphilis (Stirland 1991, 1994).

Syphilis was also reported from Gloucester, England. A virtually intact skull, dated the mid-15th century, displays healed stellate lesions and destructive gummatous lesions with little repair. The nasal aperture was also affected by both destruction and remodeling. Postcranially, the skeleton had extensive osteoproliferative lesions on the ribs, clavicles, scapulae, sternum, both humeri, right forearm, right ilium,

both femora, tibiae, and fibulae (Roberts 1994).

A syphilitic skull was discovered in Spitalfields Market, London. Morant and Hoadley (1931) describe it in the following way: "No. 131 is affected by advanced syphilis which was almost certainly the cause of death. It is probably a female. The three main sutures are obliterated but the teeth are only slightly worn. Nearly all the surfaces of the frontal and parietal bones are eroded and there is a hole in the frontal. The mastoid region of the right temporal is also affected, but the left temporal bone was untouched. The left side of the facial skeleton is missing. The right molar has been excavated by the disease" (Morant and Hoadley 1931:222). With the classic "worm-eaten" appearance, the diagnosis of syphilis in this case is unquestionable (Brothwell 1961; Steinbock 1976). Historical records suggest that the site was part of a cemetery within the churchyard of St. Mary Spittle from A.D. 1197~1537.

Dawes and Magilton (1980) mentioned two cases of syphilis in their excavation report of St. Helen's Cemetery, York, Britain. Specimen 5556, radiocarbon dated 1265~1389 A.D., is a fragmentary skull of a man, 25~35 years, with widespread gumma of the external surface of both parietals and the frontal bone. They wrote": One calvarium, with the face missing, had signs of purulent infection that could have been syphilis (5556, PI. XId)" (Dawes and Magilton 1980:58).

Another specimen (5113) is a young adult male with generalized periostitis of the left femur, both tibiae, left fibula, humerus and clavicle. It seems that a diagnosis of treponematosis would be convincing. An unpublished report by May mentioned a treponematosis specimen, dated 1459~1487 A.D., from Ipswich (Roberts 1994).

Power (1992) reported a juvenile (B253), dated from the 14th~15th centuries A.D., from Waterford City, Southern Ireland. The lesions in the Waterford case affect both the cranial and postcranial remains. The affected bones are both ulnae, the left radius, both humeri, the left scapula, both tibiae and fibulae and the skull. All long bones are characterized by periosteal new bone formation and sinus formation is evident on the distal ends of both humeri. An oval-shaped lesion on the mental eminence of the mandible, and a small indentation on the glabella of the frontal bone were also recognized. Power (1992) believed that the bony proliferation, sinus tract formations, and the bilateral and widespread nature of changes all suggest syphilis. Forty individuals from Waterford City also exhibit similar postcranial lesions. Of these individuals 83% are affected by lesions of the long bones and in 57% of cases with long bone involvement, the lesions are bilateral. The tibiae have the highest incidence, followed by the fibulae (Power 1992).

At Hyeres, Var, France, an old woman with a seven-month-

old fetus in her pelvic cavity was excavated from a cemetery that was in use between the 3rd and 5th Centuries A.D. The study of the fetal skeletal remains suggests a case of congenital syphilis. The lesions of the fetal remains include periosteal appositions on the skull vault, signs of periostitis on the long bones, some infraperiosteal detachment with paradiaphyseal calcification, and loss of metaphyseal substance of the long bones. The effect of taphonomic processes was considered and positive lesions indicated they were in vivo processes (Palfi et al. 1992).

A skeleton discovered at Calvados, France shows frontal destruction, osseous nodules on both parietals and periosteal apposition on both tibiae. These lesions suggest a treponematosis with a rhino-maxilla syndrome (Blondiaux and Bagousse 1994).

Madrid (1986) mentioned specimens from Helgeandsholmen cemetery, Sweden, which was in use between 1300 and 1531 A.D., showing signs of syphilis. However, the detailed information is not readily accessible.

During age and sex estimation research on historic skeletal series dated between the 13th and 17th centuries from Breda, Netherlands, a male incomplete skeleton was noted with a cranium having probable radial scars or superficial cavitations on the anterior skull vault. The cranium has antemortem erosion and porosities on the frontal and parietal

bones, similar to caries sicca which is characteristic of syphilis. There is a large gap in the skull vault with thinned and smooth edges. The postcranial bones have some of the traits associated in the literature with syphilis and do not seem to be caused by osteomyelitis. The cervical vertebrae C2 through C5, the medial and lateral facets of right and left clavicle, the radii, humeri, tibiae, and femora are affected (Brooks et al. 1994).

In Poland, three uncertain cases of pre-Columbian treponematosis are reported. One case comes from Suraz, Lapy district (11~14th C.). Syphilis may have caused lesions on the palate bone. The second case comes from Czarna Wielka, Grodzisk District (12~14th C.) with a thick, rough, and porotic skull. Also at the same site, a single tibia shows a generalized reaction of the periosteum with thickened cortical layer, and partially obliterated medullar cavity (Gladykowska-Rzeczycka 1994).

The analysis of 272 skeletons, dated 6th~3rd Century B.C. from the Ancient Greek colony of Metaponto, by Henneberg and Henneberg (1994) revealed signs of treponematosis in 47 individuals. Among the signs are skull vaults (Tomb 218 and Tomb 484) with the "worm eaten" patterns and sclerotic healing, "saber-shin" tibiae in two males (Tomb 53-4 and Tomb 276-1), and subperiosteal bone deposits on approximately 10% of long bones. Two juveniles (Tomb 320 and Tomb 306) had

changes on the enamel of first molars resembling the "mulberry" pattern and one of them had also slightly notched incisors.

Gladykowska-Rzeczycka (1994) also mentioned that Rokhlin and Rubaszeva had observed syphilis among osteological materials from Priladoze, Russia dated from 10th~12th centuries. In Diseases of Ancient Men, Rokhlin (1965:291) wrote:

> Doubtless evidence of syphilitic lesions have been found in precolumbian days. The most ancient finds of the kind are dated to the middle of the II millennium B.C. In the same region 3 more cases of syphilis have been found in people that lived in the I c. A.D. A number of similar finds have been made in skulls and tubular human bones dated to X-XI c. c. There are separate finds of the same nature made in lake Ladoga region, XI-XII c. c., in Eski-Kermen, V-XII c. c.. One instance of lesions resulting from tabes dorsalis, I. e. postsyphilitic lesions has been observed in Sarkel in barrows of the X-XII c. c. However, those were individual and not mass syphilitic cases, the latter remaining typical for Western Europe of the postcolumbian epoch; similar lesions have also been found in a great number of skeletons in burials of old Vyatka.

Marcsik (1994) referred to several osseous syphilitic cases from Bulgaria. Three cases came from the 9th and 10th centuries, and the other individuals from the 12th~14th centuries. A skeleton with very characteristic syphilitic lesions has been described in Denmark by Moller-Christensen and dates from the late Middle Ages or about 1500 A.D.(Steinbock 1976).

Evidence of pre-Columbian treponematosis in Africa is sparse. Steyn and Henneberg (1995) reported a case of

treponemal infection from the Mapungubwe complex of sites, South Africa. The sites date from A.D. 1000~1300, representing the early stages of the Late Iron Age in Southern Africa and remain in question, A1732 is a nearly complete skeleton of a 20-year-old male. Both tibiae, fibulae, femora, and the right humerus are affected by subperiosteal bone growth. The changes are confined to the surface of the bone and lesions are mostly bilateral. Therefore, treponemal disease is the most likely diagnosis. Other diseases, including leprosy, tuberculosis, fungal infection, Paget's disease, pyogenic osteomyelitis, and neoplasm, are discussed and excluded by the authors.

Asian skeletal evidence of pre-Columbian treponematosis mainly comes from China and India. Zhang (1994) reported a female pathological skull dating to Song Dynasty (A.D. 960~1274) from Fujian, China. The worm eaten appearance of the frontal bone and stellate scars in the glabella region indicate syphilis. A right distal tibia, probably from the same individual, exhibits extensive porous gummatous periostitis and slight raised bony spicules over superficial blood vessels in the lateral side of the distal end.

A single bone, the left femur of a female adult, from the burial site near Shanxi, dating to the Han Dynasty (200 B.C.~ A.D. 200) was also reported. The outer surface of the diaphysis is generally smooth with isolated regions of slight

porosity and the isolated plaques (Zhang 1994).

Remains from India also provide evidence of pre-Columbian treponematosis including syphilis. Rao et al. (1996) attribute specimens from Agripalle, Andhra, India to treponemal infection. An Iron Age skull of an adult male about 50 years old exhibits extensive erosion of the calvarium, areas of sclerotic diploe, irregular osteitic and periosteitic lesions, and deep ulcerations with a granulomatous appearance of nodular foci due to bone remodeling. The postcranial skeletal elements are too fragmentary to add any useful diagnostic information. Two parietal fragments from another individual display similar patches of surface erosion and redeposit, suggesting the same pathogen that produced the lesions on the first skull. Other diseases, such as Osteomyelitis, leprosy, severe anemia, osteosarcoma, and tuberculosis, were considered and excluded. The smooth, shinning surface of masses of redeposited bone on the occipital invalidates postmortem erosion. These findings warrant a diagnosis of an advanced stage of syphilis (Rao et al. 1996).

Kennedy (1990) mentioned a specimen (no. BTK-111-F-16) from an Iron Age cave at Bhimbetka, India showing a crater-like depressed area extending 23mm on the left parietal bone. Absence of perforation of the endocranial surface and moderate thickening of the bone surrounding the depression on the endocranial surface suggest cranial yaws.

Brothwell (1976) described a skull, LK. A3(5), excavated by Woodfield from Sarawak. The associated Chinese Ming period ceramics suggest a date of 16th century. The skull consists of most of both parietals and all of the frontal except for the region immediately above the nasal bones. Based on the fact that the involvement of yaws consist of a few crater-like depressions located in the frontal bone (Hackett 1951), it is more likely to be syphilis. Probably, the origin may be related to China. Stellate fissuring, areas of smoother bone, and some deep irregular craters, are found on the frontal and parietals. However, lesions are more pronounced on the frontal than on the parietals.

Stewart and Spoehr (1952) described a skull from the Mariana Islands, dated circa A.D. 854±145, with crater-like lesions on the frontal bone. They concluded that yaws has been present among the peoples of Western Pacific since prehistoric times.

Evidence of treponematosis from pre-contact times has been reported from the tropical Pacific island of Tonga by Pietrusewsky (1971). Thirteen individuals with lesions from a series of 99 individuals were mentioned. "Typical lesions were found on ribs, humeri, radii, ulnae, tibiae, fibulae, metatarsal bones(?), vertebrae(?), and crania. Even though bone representation was not equal, the tibiae seem to be the bones affected most often (35.7% of the individual cases) and

most severely. The fibulae and ulnae were also frequent sites" (Pietrusewsky 1971:336). Multiple foci of cratering and new bone formation were found on the skull of specimen To-At-1-21-A.

Skeletal Remains from the New World

The existence of treponematosis in the New World in pre-Columbian times is questionable, based on evidence from skeletal remains. A critical review of syphilitic New World remains will demonstrate that the evidence of syphilis is not as strong as the supporters of the Columbian hypothesis believed.

Most of the North American evidence for syphilis comes from Southeastern United States. The earliest discussion of skeletal evidence of syphilis in the New World is usually attributed to Jones (1876), who published a monograph on his studies of Indian remains from stone graves and mounds in Tennessee. No illustration of the bones in question were made. Williams (1932) said that "From the descriptions it appears to me that some, if not all, of these bones were syphilitic." Williams examined the skulls in the Jone's collection at the Museum of the American Indians, Heye Foundation, in New York City and found one skull with stellate scars. However, the date of the site is not definite. In 1876, Jones believed that the bones could not be less than from one hundred and seventy-

five to two hundred years old, and that they might be much older (Jones 1876). No items of European manufacture were found associated with these bones, but it is possible that the graves and mounds were made after Whites arrived in the area (Williams 1932).

Lamb (1898) described syphilitic lesions in a skeleton from a series of 74 skeletons excavated by Clarence B. Moore at Lighthouse Mound situated in northeastern Florida. Lamb said": The skull was not sent and its condition is not now known. In the present state of our knowledge I know of no disease except syphilis in which a series of bones of the same skeleton show the lesions illustrated and described." Williams (1932:968) checked the bones and said": It was my opinion that they were in all probability syphilitic. It seemed somewhat doubtful that the bones could be regarded as certainly pre-Columbian, although archaeologists have had a high regard for Moore's work." The diagnosis of syphilis without the skull is not reliable, because bone lesions of syphilis of individual lesions cannot be elicited with certainty (Hackett 1976). Williams (1932:800) stated "the skull is most important . . . " Regarding the long bones, he wrote": involvement of two or more bones of the extremities is in favor of this diagnosis." Therefore, Williams' saying "they were in all probability syphilitic" is not consistent with his diagnosis criteria for syphilis.

FSM 97527, from the Palmer Burial Mound in Osprey, is one of the most famous specimens from Florida. The skull of this specimen shows characteristic changes of syphilis, namely, "The frontal bone in particular shows new resorptive foci and stellate scars surrounded by dense, sclerotic repair bone (Bullen 1972). Referring to this specimen Hackett (1976:110) stated that it "had changes rather like sicca." Lesions on several long bones support the diagnosis. This site belongs to the Weeden Island time period, A.D. 850~1350, so, it is unquestionably pre-Columbian in date. However, Hackett also pointed out that:

> It should be stressed that the changes in these two skulls (Palmer and Moundville) are not what would be called typical caries sicca, in which the nodules are smaller and of more regular size, nor would they be chosen to illustrate carries sicca (Hackett 1976:110) . . . There is no doubt that an infection was present in these bones of Bullen. What is in doubt is whether, apart from the two skulls referred to above, the other changes in long bones, unsupported by diagnostic criteria, will allow the author's conclusion "The data presented in this report clearly demonstrate the presence of syphilis in Florida before the arrival of Europeans"(Hackett 1976:111).

Another specimen (FSM 94387) recorded by Charles E. Snow (1962) from the Bayshore Homesite, St. Petersburg is characterized by bloated femur, tibia, and phalanx that are suggestive of syphilis. However, the diagnosis is not definite without the skull. Bullen (1972:166) believed that "syphilis may have been present in a recognizable form as early as 3300 B.C. in Florida," because several pathologic long bones of one

skeleton were excavated at the Tick Island Archaic site. Also, "Skulls are crushed and not yet in condition for study" (Bullen 1972:166). Therefore, syphilis is only a possible cause of the bone lesions.

Hutchinson (1993) analyzed mortuary populations, dated from the late prehistoric and early historic periods, from safety Harbor, Tatham, Weeki Wachee Mound, Tierra verde, and Aqui Esta, Florida and the result indicated the presence of a treponemal disease prior to European contact. Comparison of the lesions with those observed in modern studies of treponemal infection does not support an interpretation of venereal syphilis. "Cranial lesions of 'caries sicca' and larger areas of 'gummatous' remodeling, often taken to be a classic sign of venereal syphilis, are rarely present in this study sample and are not reported in other studies of prehistoric or early historic skeletal remains from the Gulf Coast region" (Hutchinson 1993:257).

Treponemal infection has been found in a prehistoric skeletal series from Georgia (Powell 1988). However, the demographic and anatomical patterning of skeletal lesions indicates non-venereal treponematosis rather than syphilis.

In an article about the dental conditions among prehistoric Indians of Northern Alabama, Rabkin (1942) mentioned a skull with perforated palate and healed border of bone suggest the possibility of gumma. Without diagnostic

lesions of the cranial vault, a diagnosis of syphilis cannot be reached. In addition, no specific proveniance of the specimen is provided. The skeleton of an adult female exhibiting treponemal infection was reported by Reichs (1989) from the Hardin site, North Carolina. "The skeleton is affected by a diffuse process resulting in surface changes, both destructive and appositional, node formation and shaft expansion, medullary encroachment and filling, cortical thickening and fracture" (Reichs 1989). Reichs (1989) suggested it was a case of nonvenereal treponematosis.

Ortner and Putschar (1985) reported a six to seven-year-old American Indian child with congenital syphilis from Virginia (NMNH 379177). Both the pottery types and the presence of stone pipes suggest a pre-Columbian date. In this case, the frontal, nasal and adjacent maxillary bones, the ulnae, tibiae, and first and fifth metatarsals are affected. The frontal, nasal, and maxillary bones exhibit porosity. The nasal bones and nasal aperture have thickened, porous, periosteal bone on their external surfaces, all of the major bones of the postcranial skeleton exhibit porous periosteal changes. Both right maxillary incisors have marked hypoplastic enamel defects and there is a less severe hypoplastic defect on the left deciduous maxillary canine. The first permanent molars are normal. Ortner and Putschar (1985) argued that the position of the marked hypoplastic defect on the incisors

suggests that it could only have occurred at about the seventh fetal month. However, hypoplasia is a condition often found with but not diagnostic of congenital syphilis (Bradlaw 1953 and Powell 1994). Steinbock (1976) proposed that hypoplasia may also be present with rickets. For this specimen, periostitis is present but typical change such as saber-shin tibiae were not found. In addition, the dental stigmata characteristic of congenital syphilis are not found. Therefore, the diagnosis of congenital syphilis cannot be reached by dental stigmata shown on this specimen. It is very likely that this specimen was suffering treponematosis but the specific type is unknown.

The Veddar site, dated about 500 B.C., in the Mohawk Valley of New York state demonstrates evidence for treponematosis (Elting and Starna 1984). This is the only evidence reported from the Northeastern North America. "The specimens consist of two tibiae and two fibulae which appear to be from the same individual." All bones are afflicted with a diffuse process that has laid down new bone in irregular patterns and the medullary canals are narrowed. Elting and Starna (1984) argued that the focal nodes or expansions with superficial cavitations described here are diagnostic of the treponematoses. "Coupled with the cortical formation, and the comparison with known specimens, a diagnosis of treponematosis is reasonably secure" (Elting and Starna 1984). The diagnosis

of syphilis was not reached because the skull is not available.

Morse (1967) examined a skeleton excavated by Burt from the Rose Mound Group, Schuyler County, Illinois. The cultural affiliation of the materials was principally Mississippian, which dates around A.D. 1,200~1,400. The skull shows considerable nasal destruction and part of frontal bone exhibits irregular pits and sinus formation. The post cranial skeleton is also involved and some ulcerative osteomyelitis were found on the shafts of both tibiae and other bones also have some lesions. Another case, dated 1,000 A.D., mentioned by Morse came from Fulton County, Illinois. The anterior surface of the frontal bone is characterized by subperiosteal thickening. There are several small holes, which involve only the outer table, above the eye sockets. The right tibia suffered hypertrophy and there are many tiny pits on its surface. Some ribs show thickened irregular surfaces with bone destruction and nodulation. Both femora, right humerus, right radius, and right ulna were also involved. Both of the cases may be a treponemal infection, but the specific types of infection are unknown.

Cassidy (1980) reported cases of treponematosis from Hardin Village (A.D. 1525~1675) and Indian Knoll (3350 B.C.), Kentucky.

This syndrome is characterized by changes in the long

> bones, particularly those of the legs, consisting of thickening, and the development of either stripes of smooth billowed material or patches of rough porous material on the surfaces of the bones. Some diminution of the marrow spaces occurs in advanced cases by endosteal apposition. In very young children the bones, on x-ray, show layering, the so-called "onion-skin effect." This morphological picture, taken together with historical and medical data (Cassidy, 1972) suggests the identification of the disease as a treponematosis (Cassidy 1980:137) . . .

Among the Middle and Late Woodland populations, a high frequency of cranial and long bone lesions has been noticed by researchers (Buikstra 1979). In her Ph.D. dissertation, Cook (1976) argued that the high prevalence of the disease made it unlikely to be a venereal treponematosis. She pointed out that congenital syphilis was not identifiable in Woodland infants. Therefore, the disease that best fitted those prehistoric populations' pathological patterns would be the nonvenereal, endemic forms of treponematosis.

From a California site (Sonoma 299), Roney (1966) mentioned an individual with periostitis located on the tibia and fibula and less severely on the clavicle, radius, and cranium. He said "the distribution and characteristics of the lesions suggest syphilis (Roney 1966:102)" without describing whether characteristic lesions were present on the skull.

From the Kinisuba and Vandal Cave in Arizona, excavations revealed fifty-seven individuals, two of which are suspected of suffering from syphilis (Cole et al. 1955). Tree-ring dates at Kinishba ranges from A.D. 1233 to 1306. At Vandal

Cave, they recognized two levels of occupation, the latest is prior to A.D. 1300. Evidence of disease was confined to a tibia (A-17-0-17) and skull fragments (A-11-0-17) belonging to the same individual. The skull of this specimen shows nothing characteristic of syphilis, so, the diagnosis of syphilis made by Cole et al. is not acceptable. Cole et al. (1955) argued "the tibia from the same subject demonstrates almost certain evidence of luetic infection and since syphilis is the only disease which could have produced the changes in both bones, it is reasonable to consider the lesion of skull as probably the result of syphilis." In fact most specialists in this field, such as Williams (1932), Steinbock (1976), and Ortner and Putschar (1985), purposed that one cannot make a definite diagnosis of syphilis based on a single bone.

Regarding an isolated right tibia (V1-B-5), Cole et al. (1955) believed that the changes were those of classical saber shin deformity of congenital syphilis. Again, it is really hard to reach this conclusion on one bone. As Williams (1932:787) said ". . . the diagnosis of . . . syphilis in a single dried bone without its clinical history would be dubious, the involvement of several bones would make a diagnosis of syphilis more plausible." Ortner and Putschar (1985:180) proposed that "The boomerang leg, which is the bending of the tibia in yaws in very similar to saber tibia of congenital syphilis . . . These changes are indistinguishable

from postrachitic deformities and may not be due to yaws alone." However, Cole et al. (1955) mentioned nothing related to differential diagnosis.

Some skeletal elements were recovered from the Bracken Cairn located in the southwestern Saskatchewan, Canada. A radiocarbon date of 2465±85 years B.P. was obtained for this burial site. The affected skeletal remains consist of the manubrium sternum, the right clavicle, and two thoracic vertebrae from an adult male. Walker (1983) believed that the presence of a mass does not usually cause osseous erosion, but rather it is the pulsatile activity of an aneurysm, syphilitic aortic aneurysms, that is responsible for this phenomenon. Syphilitic aneurysm is a manifestation of tertiary syphilis. However, bone lesions were not found on any other bones. Williams (1932:784) said": I should think the perfectly typical syphilitic skull a more certain criterion for diagnosis than a Wassermann reaction of four plus or an aneurysm of the aorta."

A critical review of Mexican skeletal collections shows that most of the pre-Columbian cases are not specific of treponematosis. Those that show typical syphilitic lesions are not precisely dated. Baker and Armelagos (1988) mentioned remains from Cueva de la Candelaria, Santiago Tlalteloco, and Tehuacan Valley. According to Goff's (1967) report, the dating of the Candelaria site does not seem well established and

ranges from the 6th to 16th century. Another report from Aveleyra et al. suggests an archaeological chronology between the 11th and 17th centuries (Mansilla and Pijoan 1994). The prehispanic chronology of Tlatelolco site has been established as 1300 to 1521 AD., but this area continued to be a burial place until this century. The example mentioned is an isolated case with doubtful location and chronology (Mansilla and Pijoan 1994). The specimen from the Tehuacan valley was described by Anderson (1965) and it corresponds to the Santa Maria Phase. The reported skull is incomplete, almost lacking the cranial vault. There is a mixture of destructive and proliferative lesions on the outer table. However, the postcranial skeleton does not exhibit any lesions suggesting treponemal infection. X-rays of all long bones suggest a neoplastic disease, although the cranial lesion could be treponematosis (Mansilla and Pijoan 1994).

Inflammatory lesions in twelve individuals buried at Altar de Sacrificio, Guatemala, before 950 A.D. suggest treponematosis, but no sign indicates the existence of syphilis. Continuous pitting and cratering cover the frontal and parietal bones of Burial No. 129. However, interpretation is complicated by the possibility of postmortem damage by insects. Burial No.96 exhibits isolated marked pits in the external frontal bone and lesions diagnostic for syphilis are not observed. "Postcranial lesions were found in various bones

and involve varying degrees of enlargement or thickening of the cortical or dense outer layer of the diaphysis or shaft together with varying degrees of distortion" (Saul 1972).

Three cases of possible syphilis were reported by MacCurdy (1923: 264) from the Urubamba Valley, north of Cuzco. The cranium of a child from Paucarcanda showed a considerable area of necrosis on the frontal and left parietal. "MacCurdy made a diagnosis of probable syphilis, but as no new formation of bone was mentioned, I should think that was doubtful" (Williams 1932:972). Another cranium of a child from Patallacta, with a circular area of necrosis 4.2 cm in diameter, is also denied as syphilis by Williams (1932:972) for the same reason. For the third case, Williams said": From the photography (MacCurdy's Plate XL1) I should think that this might well have been a case of syphilis." The date of the cases is not definite, because MacCurdy (1923:264) wrote": Some of the burials in the highlands of Peru were evidently post-Columbian."

Although the existence of syphilis seems to be unquestionable in the New World, the above critical review shows us that many cases of syphilitic skeletal remains are atypical or unacceptable or suffering some problems. Therefore, syphilis cannot be demonstrated to exist in the New World based on the skeletal remains we have.

Microbiological Evidence

A discussion of microbiological evidence will demonstrate whether the pathogens of treponematosis are one species of organism, which is important for our understanding of the relationships among syphilis, bejel, yaws, and pinta.

Spirochetes are helically shaped, heterotrophic bacteria (Canale-parola 1977). The first description of regularly waved spirochetes was made by Donne in 1837 (Hovind-Hougen 1983). Schaulin and Holfman described the morphology of *T. pallidum pallidum* in 1904 (Hovind-Hougen 1983). The body of the cell consists of the cytoplasmic and nuclear regions enveloped by the cell membrane and the cell wall. A three-layered membrane called the "outer sheath" completely surrounds the body of the cell, which is wound together with a number of filamentous structures called axial. All bacteria possessing the above morphological characteristics are spirochetes, or members of the order *Spirochaetales* (Canale-parola 1968).

Based on morphological and physiological traits, the members of the order *Spirochaetales* are divided into five genera, *Spirochaeta*, *Cristispira*, *Treponema*, *Borrelia*, and *Leptospira* (Holt 1978). The genus *Treponema* includes four human pathogens (Table 1). In Bergey's Manual of Systematic Bacteriology (Smibert 1984). The species *Treponema pallidum* includes three of the human pathogens: *T. pallidum pallidum*,

T. pallidum pertenue, and *T. pallidum endemicum*. Because of the lack of genetic information *T. carateum* remains as a separate species.

In 1928, Noguchi (1928) stated that *T. pallidum pallidum* and *T. pallidum pertenue* were morphologically indistinguishable. Angulo et al. and Watson et al. 's studies of shadow cast material by electron microscopy demonstrated no morphological differences between *T. carateum and T. pallidum pertenue* when compared with *T. pallidum pallidum* (Hovind-Hougen 1983). Using a Zeiss 902 electron microscope, Engelkens et al. (1991) proved that *T. pallidum pertenue* shows an ultramicroscopic morphology identical to *T. pallidum pallidum*.

TABLE 1
CHARACTERISTICS OF HUMAN TREPONEMATOSES

Organism	Disease	Distribution	Transmission
T. *pallidum pallidum*	Syphilis	Worldwide	Sexual contact
T. *pallidum pertenue*	Yaws	Warm, humid areas	Skin contact
T. *pallidum endemicum*	Bejel	Warm, arid areas	Mucous membrane and skin
T. *carateum*	Pinta	Semiarid, warm areas	Skin contact

Miao and Fieldsteel (1980) demonstrated the complete DNA sequence homology between *T. pallidum pallidum* and *T. pallidum*

pertenue using DNA sequence homology by DNA-DNA saturation reassociation assays, namely, they are genetically indistinguishable. According to this result, Smibert classified the two as subspecies of *T. pallidum* with different degrees of virulence.

In a study to serologically differentiate syphilis from yaws, 69 monoclonal antibody species raised against *Treponema pallidum pallidum* were tested by immunoblotting for their reactivity with *Treponema pallidum pertenue*. All monoclonal antibodies reacted with antigens with the same molecular weight in both subspecies. In addition, no differences in reactivity between sera from yaws and syphilis patients were found by Western blot analysis of cell lysates of *T. pallidum pallidum* and *T. pallidum pertenue* (Noordhoek et al. 1990). Noordhoek et al. (1990) tried to exploit the only known molecular difference between the *Treponema pallidum pertenue* and *Treponema pallidum pallidum*. The subunits of proteins TpF1 of the two subspecies have previously been shown to differ in one amino acid residue at position 40 (Noordhoek et al. 1989). However, no difference was found in immunoreactivity between them (Noorhoek et al. 1990). Synthetic peptides based on the sequence of two kinds of TpT1 were used in an enzyme-linked immunosorbent assay and no difference in reactivity between the peptides was observed.

Ferris and Turner (1932) suggested that the histologic criteria for differentiating yaws and syphilis are not reliable. Wicher (1983) proposed that the pathology of experimental animals caused by *Treponema pallidum pertenue* and *Treponema pallidum pallidum* are very similar. As Engelkens et al. (1991:235) asserted, "The histopathologic picture (of bejel) closely resembles that of venereal syphilis" and "The histopathologic changes in pinta are largely similar to those in Yaws" (1991:233).

The above discussion shows the pathogens of the treponematoses are almost identical considering their morphology, biochemistry, immunology, and histology.

Clinical Evidence

The reason why we have different names, such as syphilis, bejel, yaws, and pints for one kind of treponemal infection is that they are clinically different. Therefore, an analysis of the origin of these differences is indispensable.

The clinical manifestations of treponemal infections differ in some respects but these differences can be largely explained by difference environmental influences and by the probable subsequent adoption of certain biological characteristics by treponema (Hudson 1946). In addition, a review of medical literature indicates that the clinical differences between the treponematoses can be ambiguous. The

clinical and epidemiological differences appear to be rather of a quantitative than of a qualitative nature. Atypical treponemal infections are easily found and a diagnosis may be hard to reach. Sometimes, it is very difficult to decide which kind of treponemal infection a patient is suffering from on inspection of individuals. The patient's history and country of origin are important factors in the diagnosis. Diagnosis can be difficult in regions where syphilis and nonvenereal treponematoses are simultaneously prevalent (Engelkens et al. 1991).

The climate is a factor that influences the distribution of treponemal infections, but it is not a determinate factor. The "sibbens" of the British Isles in the seventeenth century, the "radesyge" of Norway in the eighteen century, the "skerljevo" of the Croatian coast in the nineteenth century (Grin 1956), and the "spirocolon" of Greece (Morton 1967) are old examples of bejel not found in warm arid areas. The outbreaks of bejel in Poland after the second world war, in the slums of Chicago (Luger 1972), in Bosnia (Grin 1953), and in Hungary (Luger 1972) also show that bejel is not limited to warm arid areas. Morton (1967) wrote that it was a well-known fact that yaws was recognized in England and was adequately described by Sydenham in 1681. Some might think the two diseases, yaws and sibbens, to be one and the same, the alteration of presentation being affected by climatic and

social conditions (Morton 1967). In fact, climate does affect the clinical manifestations of treponematoses. Atypical or mild yaws was found in areas where the prevalence had not been reduced by treatment but had always been low because of climatic circumstances not conducive to the transmission of yaws, such as higher altitude and low humidity (Vorst 1985). Atypical yaws is characterized by one or a few lesions, generally confined to the skin folds. These transient lesions are flat, dry, and gray (Koff and Rosen 1993). In many endemic areas, such as the Caribbean, Indonesia, and the Pacific, atypical yaws prevails in high-altitude areas. In West Africa, where fully developed lesions were prevalent in the humid coastal forest belts, mild lesions were prevalent in the drier savannahs away from the coast (Vorst 1985).

Social factors can affect the distribution of treponematosis. In Saudi Arabia, 2515 patients attending a military hospital were studied clinically, radiologically, and serologically for evidence of treponematosis. The result indicated that bejel is prevalent among the nomadic communities living in rural areas. On the other hand, venereal syphilis is much less common, and is found almost exclusive in urban populations (Pace and Csonka 1984). Another report by Pace (1983) suggested that the Bedouin populations born and bred in primitive surroundings are at great risk for bejel but appear to be resistant to syphilis. On the other hand, the

townspeople who do not get bejel by virtue of their hygienic condition may develop syphilis if exposed to it. According to a report on a survey in the Sudan, in some villages of the Nuba Mountain region, it was possible to establish how the first syphilis infection was imported and then spread as non-venereal bejel on account of the generally low hygienic and living conditions of the population in the rural areas (Grin 1961).

The causes of atypical treponematoses can be unrelated to climate. In Saudi Arabia, bejel has changed appreciably within a generation, having been replaced by a milder form in which the number, severity, and duration of both early and late lesions are reduced. The cause of the this change is not clear (Pace and Csonka 1984). Pace and Csonka (1985) hypothesized that improvements in hygiene may play an important role. Yaws was highly prevalent in Surinam, a tropical country in northeastern part of South America, at the beginning of this century. Although no mass treatment campaign against yaws was undertaken, a survey indicated attenuated yaws in the central, northern region of Surinam. This may be related to improved living and hygienic conditions (Niemel et al. 1979).

The mode of transmission of the various treponematoses seems to be quite different. However, a close investigation of the mechanisms indicates that the methods of their transmission are quite similar. Syphilis is not necessarily a

venereal disease and it can also be transmitted by skin-to-skin contact. Kissing or touching a person who has active lesions on the lips, breasts, or genitals can also spread syphilis (Tramont 1995). On the other hand, a patient may inoculate syphilis to the area on the body that is kissed. In Europe, the use of a wet nurse was a socially recognized status symbol, but wet nurses often spread the disease to infants. Handling infected clinical materials may result in accidental inoculation. In fact, syphilis of the fingers is most common in medical personnel (Tramont 1995). Three children with syphilitic alopecia, mucous patches, and condylomata late were seen in Vienna in 1968 (Luger 1972). The infection was transmitted from a woman to the three children. All the findings indicated that the children could not have contracted the disease by venereal contact, and a non-venereal infection, favored by crowded housing conditions and poor hygiene, had therefore to be assumed (Luger 1972). The Municipal Social Hygiene Clinic of the Venereal Disease Control Program, Chicago Health Department, reports 20 cases of asexually acquired syphilis in Children under 10 years of age (Eisenberg et al. 1949). Overcrowded home conditions and bad hygienic conditions are attributed to the acquisition of syphilis asexually among children exposed to infectious syphilis. Grin (1956) argued that the crucial element responsible for the frequency of congenital transmission in

syphilis is the high level of treponeme in a recently infected mother's body during pregnancy. For early stages, the level is high and the chance of transmission is good. In syphilis, infection of the fetus in utero is most likely to occur during the early stages of the infection and the risk of fetal infection decreases progressively thereafter (Tramont 1995). This venereal transmission is also unusual when the mother has been infected for more than five years (Hackett 1963). In nonvenereal treponemal infections, the patients usually acquired the disease in early childhood. Since the infectiousness decreases with time, the probability of congenital transmission of the treponematosis is reduced (Hackett 1963; Turner and Hollander 1957; Grin 1956).

A study in Java showed that yaws can be transmitted congenitally. The negative status of the baby was related to the mother's treatment. However, it is not related to mother's treatment five months after birth. This refutes the argument that infections are acquired from the mother during or after delivery. Furthermore, "mother yaws" could not be demonstrated in very young children with positive serological tests and destructive bone and joint lesions, also proving that yaws can be transmitted congenitally (Engelhardt 1959).

The different sites of primary lesions can be related to environmental influences, because the primary lesions of treponemal infections occur at the place of inoculation. In

syphilis, the chancre will be located wherever the inoculation occurred and the external genitalia are obviously the most frequently involved sites. Other common sites include the cervix, mouth, perianal area, and anal canal (Tramont 1995). In yaws, the initial lesions are most frequent on the legs and feet, owing to scratch or abrasions by plants on the uncovered parts of the body (Grin 1956). In bejel, it occurs in the oropharyngeal mucosa through the sharing of domestic utensils and kissing or on the nipples of a nursing mother. The initial lesions of pinta begin on the extremities, face, neck, chest, or abdomen (Chulay 1995). According to Hollander's theory, there is a recognizable relationship between environmental temperature and lesion distribution in the respective treponemal syndromes. In experiments, intravenously inoculated rabbits in a cool environment developed lesions on cool, shaved areas of the body but not on warmer areas protected by fur or on the head and ears which are colder. "Interaction between the environmental temperature and the temperature gradients in the host seemed to determine the areas with optimal temperature for the growth of treponemes" (Hollander 1981).

The appearance of primary lesions can also be related to other influences. The rarity of primary lesions in bejel and their relative frequency in yaws can be related in differences in the size of inoculum (Grin 1956). In yaws the inoculum is

massive because of trauma and the abundance of infectious lesions rich in treponemes under favorable environments. In bejel the infection usually occurs by the transfer of a small number of organisms under unfavorable environmental conditions resulting in fewer primary lesions. In syphilis, atypical lesions or the absence of primary skin lesions are also common (Tramont 1995). Engelkens et al. (1990) reported that a child, born and living in Indonesia, experienced disseminated skin lesions and an ulcerated, crusted, papillomatous lesion on the prepuce of his penis. This location suggested syphilis, but based on clinical, serologic, and epidemiologic grounds a diagnosis of early yaws was made. Most likely the genital lesion was acquired by autoinoculation, namely, finger contact with an earlier lesion that was rich in treponemes.

For the late stages of treponemal infection, bone and joint lesions are present in syphilis, yaws, and bejel, and show no essential differences in appearance. Minor differences in yaws include less frequent destruction of the nose and more common deformity of the phalanges.

Syphilis is regarded as the only treponemal infection that affects cardiovascular and neuro-ophthalmological systems. However, a review of literatures may offer some exceptions to this rule. In 1923, Hunt and Johnson (1923) reported interstitial keratitis among Samoans with yaws. Wilson (1934) studied a series of 424 consecutive cases of

yaws in Darien, Panama, and reported that yaws may be the accidental etiological factor in aneurysm and cerebral thrombosis or cerebral hemorrhage of young adults. In 1969, a team of investigators flew to Caracas, investigating a group of 123 patients having cases of late yaws or late pinta, and matching controls. The emphasis of the study related to neuro-ophthalmological effects of late yaws and pinta. Eye lesions were present in several patients with late yaws. One patient with pinta suffered interstitial keratitis. These findings were often subclinical and required refined instrumentation for discovery. A case of yaws had features of primary optic atrophy of insidious onset without probable neurological cause was reported by Mohamed (1990). The most significant finding was the detection of spirochetes in the aqueous humor of two patients with late yaws. Some abnormalities, such as elevated IgG levels, were noted in the cerebrospinal fluids of patients with late yaws (Smith 1971). Roman and Roman (1986) examined 902 patients with yaws and found that 25% of them had cerebrospinal fluids abnormalities.

Since the introduction of penicillin, the clinical manifestations of syphilis have been strikingly changed. In many areas, exuberant secondary skin lesions are rare now and gummata have virtually disappeared in many places. Early congenital syphilis has also become very rare (Willcox 1974). With the development of medical sciences, the clinical

manifestation of other treponematoses has also been changed. Receding yaws may be found in communities where casual treatment, which is treatment of patients seeking it, has been available for many years. It is characterized by decreased frequency of transmission and reduced severity of the disease, namely, the complete absence of active gammas and the infrequency of late ulceration. Few or no patients have clinically active lesions and the lesions present are probably hyperkeratoses. A characteristic papillomatous stage of receding yaws is characterized by scantiness of papillomata in even the most heavily affected patients, which are usually dry. It is quite similar to atypical yaws found at high altitudes in endemic areas, such as Caribbean, Indonesia, and dry savannahs in West Africa. Therefore, medical treatment changes the clinical manifestations of treponematosis in the same way as the environment does, in fact, for the bacteria, a new medical treatment is just a change in environment However, nobody will argue that the current syphilis and the syphilis existing before the invention of penicillin are different diseases. Syphilis became milder, because those strains of the organism that did not draw attention to themselves by a marked host response would be those more likely to survive (Willcox 1974). Considering the fact that an improvement in hygienic conditions or a change of climate is just like the introduction of penicillin which changed the

manifestations of treponematosis, it may be easy for us to understand how the treponematoses could all be one disease.

Evolutionary Theories

The evolutionary theories discussed below will show the relationship among syphilis, bejel, yaws, and pinta, considering the environments. Also, it will clarify that they are one disease's different expression under different environments.

Cockburn (1963) proposed a theory mentioned by many scientists (e.g., Smith 1934; Rothchild and Clay 1952), namely, "All parasites are descended from free-living organism" (Cockburn 1963:68). Therefore, it is in the soil or water that one will find the original ancestors of the treponemes. The free-living, carbohydrate-fermenting, obligate anaerobes are the most direct descendent of the ancient spirochete, while free-living aerobic and facultatively anaerobic forms, and spirochetes indigenous to animals and humans developed through further evolutionary processes (Canale-parola 1977). *Treponeme. zuelzerae* is a descendant of the free-living organism that can be found in mud today and lives symbiotically with chlorbacteriaceae (Veldkamp 1960). Willcox (1973) suggested that the first treponemes evolved in water and were then picked up by humans and carried as commensals before becoming pathogenic. It is likely that the

loss of certain biosynthetic abilities is one of the factors responsible for the development of spirochetes restricted to life within specialized, host-associated environment. After a long time in the human body, using the substances in the human body instead of synthesizing them may have had a selective advantage through requiring a lesser number of energy-consuming biosynthetic steps for growth (Canale-parola 1977).

The parasitic diseases affecting humans consist of two types: those which were already adapted to our prehominid ancestors, and those which were already adapted to other host species and were accidentally transmitted to humans by contact (Armelagos and Dewey 1970; Cockburn 1961; Polgar 1964). Treponematosis falls into the first category. Direct skin-to-skin contact is the major route of transmission in yaws, bejel, and pinta. Breaks in the skin such as excoriations, scratches, and traumata, provide an entry for the treponemes (Engelkens et al. 1991).

As humans migrated to dry regions, such as the savanna, the clinical characters of treponematosis changed from a florid skin eruption to lesions in the mouth, axillae, and other humid areas of body. This syndrome constituted bejel (Hudson 1963a).

The emergence of sedentary village life did not alter the mode of transmission. However, treponematosis may have experienced an expansion with the appearance of sedentary

agriculture. "The propagation of treponematosis was enhanced in the village by an increase in the number of children, and by the increased frequency and intimacy of childhood contacts amid the crowded and unhygienic conditions of village life" (Hudson 1965a:893).

Hygienic conditions play an important role in Hudson's scheme for the origin of syphilis. Why did syphilis not develop sooner in the evolutionary process if all treponemal infections are the result of one organism?

> The answer is inherent in the childhood character of endemic treponematosis. Since no hygienic barriers deterred non-sexual contacts between children, and new cases were continually being initiated by contagion in the pre-pubertal segment of the population, scarcely any individual escaped infection in his early years. Consequently, as individuals reached the age of sexual activity, they had long since passed through the early stage of the disease and were in a latent or immune state (Hudson 1965a:892).

Hudson proposed that syphilis arose only with the development of advanced hygienic conditions": the availability of water, habits of washing and bathing, the use of soap, the wearing of clothing, the use of eating utensils, the control of ectoparasites, the separation of individuals in sleep and the infrequency of casual contacts between the moist skin and mucous membrane of child with child" (Hudson 1965a:895). During this transition, both venereal and nonvenereal syphilis may have existed together with more older persons being affected by the latter as the prevalence of the childhood infection waned (Willcox 1973).

Crucial to a correct understanding of Hudson's Unitarian hypothesis is the concept that the disease displays a biological gradient, "extending from the syphilis of adults in urban society at one pole, through various kinds of endemic syphilis in primitive villages of temperate and subtropical zones, to the humid tropics at the other pole (Hudson 1965a:888)." Not only does treponematosis embrace a biological gradient but also constant shifting occurs. Environmental changes may convert nonvenereal treponematosis into syphilis or vice versa (Hudson 1965a).

Fry and Rodin (1966) described Caribbean immigrant children with yaws who do not exhibit changes in clinical symptoms on arrival in Britain. Patients from yaws-endemic areas of Africa continued to exhibit the disease after moving to United Kingdom (Green and Harman 1985). Saul (1972) simplified Hudson's theory and argued that the above reports disprove the hypothesis treponematosis is a single disease. In fact, these examples cannot disprove Hudson's argument. If yaws became epidemic in the Britain and lasted for some time as yaws, it may disprove the Unitarian hypothesis.

It seems as if the social conditions in the prehistoric Americas did not favor the evolution of syphilis as highly as those of the Old World. For example, most of the North American evidence of syphilis was found in the Southeastern U.S.. The climate in the Southeastern U.S. promotes patterns

of dress that minimize physical barriers to frequent contact among individuals of all ages. Sharing of clothing, bedding, and utensils was common. Bathing was common in streams but soap was unknown. Childhood exposure to endemic treponeme provides some degree of adult immunity to later reinfection. Considering climate, clothing, domestic items, hygiene, and sexual customs, Powell (1994) argued that these factors favor bejel instead of syphilis in the Southeastern U.S.. Generally speaking, the social conditions in the New World did not select for syphilis.

Base on the evolutionary theory, we may argue that some forms of nonvenereal treponemal infection exited before Columbus's voyage in both the Old and New Worlds. With the change in social and physical environments, syphilis emerged in the Old World. However, in the New World only nonvenereal treponematoses were selected for, so, syphilis did not emerge before Europeans brought it there.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

Was syphilis present in the Old World before 1492? In the Old World, pre-Columbian skeletal remains show reasonably strong evidence of both venereal and nonvenereal treponematoses. The evidence may be even stronger considering other factors. For the Old World, most of the paleopathological investigations were limited to Europe, whereas the other areas of the Old World have not been thoroughly investigated. A review of the literature shows that very few reports come from Asia and Africa (Brothwell 1988, Vasulu 1993). In Britain, where several syphilitic specimens were found recently, Roberts (1994) suggested": the recognition of the characteristic skeletal changes of treponematosis requires training and expertise in the field of biological anthropology generally and paleopathology more particularly. It is only in recent years that training in biological anthropology in the U.K., at least, has developed."

Paleopathological investigations in Asian and African regions have only begun recently, about two decades ago. This means that research in Old World is not yet completed and therefore the available data are not exhaustive enough to draw a conclusion about the overall status of the Old World skeletal remains (Vasulu 1993). In the New World, funding and numbers of research personnel are relatively more abundant than in the Old World. More skeletal collections are examined and this increases the chance of finding more cases of treponematosis.

In the 1960s, Hackett (1963) argued that the majority of the evidence for the pathogen existing in the pre-Columbian Old World was of a mild form, not so virulent as to manifest itself in endemic proportions due to prevailing socio-ecological conditions.

Was syphilis present in the New World before 1492? Using the currently accepted diagnostic criteria, a critical review of pre-Columbian skeletal remains in New World demonstrates that almost no testable cases of syphilis exist. While nonvenereal treponematoses were wide-distributed and common, syphilis was probably not present. In contrast to the pattern proposed by the proponents of the Columbian hypothesis, the evidence for Old World syphilis is much stronger than for New World syphilis.

For the New World, even if those indefinite cases of syphilis can be accepted, a problem remains for most areas of

the New World that there is very little evidence of congenital syphilis (Baker and Armelagos 1988; Cook 1994) with the only exception being a questionable specimen from Virginia (Ortner and Putschar 1985). Since syphilis can frequently cause the infection of the fetus in utero, an overall infection rate of 84 percent in the offspring of infected mothers is found (Fournier 1899). The frequency of acquired syphilis and the scarcity of congenital syphilis are hard to reconcile.

There may be some mechanism that decreases the frequency of congenital syphilis in the New World. "Because children's bones are less likely to survive burial than adult bones, the lesions of active congenital syphilis might be infrequent in exhumations (Hackett 1976). Not all children with congenital syphilis show dental lesions, affected teeth can be lost to caries, and the distinctive features of the crowns are readily worn away (Cook 1994). Goff (1967) proposed that such teeth are described as disappearing by the age of 20 to 25 years and by that time the irregular edges have worn off. An infant with rhinitis and stomatitis severe enough to cause dental lesions may not have survived long enough to develop dental lesions (Cook 1994). However, the above factors may not be valid given the fact that no congenital syphilis with dental lesions is found in New World at all. After an examination of several thousand dentitions from North America, Cook (Cook 1990:77) concluded that "a final puzzle is the striking absence of

Hutchinson's incisors and Mulberry molars in these samples, and in prehistoric Native Americans in general." However, postcontact congenital syphilis was present in the New World. Jacobi et al. (1992) mentioned Hutchinson's incisor, apical hypoplasia of the canines, and Moon's molars in three specimens, dating A.D. 1660~1820, from Newton Plantation, Barbados.

Are pinta, yaws, bejel, and syphilis one disease or separate diseases? The clinical manifestations of treponemal infections differ in some respects but these differences can be largely explained by different environmental influences and by the probable subsequent adoption of certain biological characteristics by the treponema (Hudson 1946). In addition, treponema are not morphologically, biochemically, immunologically, or histologically distinguishable. It is not argued that the treponematoses are exactly the same. What is said is that only quantitative differences exist between them.

Does the rapid spread of syphilis throughout Europe around 1500 suggest the introduction of a virulent disease into a population that had not previously been exposed to it and had no immunity to it? Yes, it is possible, but it is not necessarily the only possibility and other explanations also makes sense. Hackett (1963, 1967) and Holcomb (1934, 1935) have argued that the epidemic around 1500 resulted from the recognition of syphilis as a disease separate from leprosy. It

was possible that bejel was prevalent in Europe in earlier times when its late manifestation without venereal transmission would have been attributed to leprosy (Willcox 1973). Later, syphilis emerged and coexisted with bejel for some times. People failed to differentiate it from leprosy. The bulls of Popes Innocent VIII of 1490, and of Julian II of 1505 abolished all "leper" asylums and released an untold number of syphilitics all over Europe (Holcomb 1934).

The association between disease and warfare has long been recognized, and warfare has been shown to be responsible for the increased spread of pathogens and increased vulnerability of hosts (Ewald 1994). A recent example is the influenza pandemic of 1918~1919, after World War I. Ten million people were killed during combat, but twice as many were killed by the influenza. Virulence was enhanced by rapid transmission among the large numbers of recruits in rapid succession. "Rapid passage of pathogens in laboratory animals, like the passage of pathogens among soldiers in World War I, may favor increases in virulence because it eliminates the requirement that hosts be mobile to transmit their infections. In the lab, the researcher and the inoculating tool comprise the cultural vector favoring the more highly reproductive and hence more virulent pathogens" (Ewald 1994:115). By permitting transmission from immobilized hosts, this cultural vector may have increased the virulence of strains that have been rapidly

transmitted in the lab setting. Therefore, transfer soon after the onset of infection selects for those pathogen variants that reproduce rapidly and early, thereby enhancing virulence.

The French King, Charles VIII, began his invasion of Italy in the fall of 1494 (Holcomb 1935). He organized an army consisting of a large number of mercenaries from France, Germany, Flanders, Poland, England, Austria, Switzerland, and other nations (Naranjo 1995). With a force of 30,000 men, he set out from Lyon for Italy. In January, 1495, the troops resumed their march to Naples. On February 22, Charles VIII led his men in triumph into that city and they turned to pillage, theft, and rape. In March and April of 1495, Charles VIII's men became seriously ill with syphilis. Because the disease was so virulent, it was fatal for many soldiers and even more returned home carrying the disease with them (Naranjo 1995). Therefore, warfare may have contributed to the virulence of syphilis around 1500 A.D..

Did mutations occur, causing one kind of treponematosis to evolve into another? Hackett envisages change from one treponematosis to another as change from one species of parasite to another by mutation at a definite time and place. Hudson did not think mutations happened. Willcox (1973) summarized the early theories of Hackett (1963) and Hudson (1958, 1964, 1965a), and postulated that: "As a result of mutation and natural selection of the varieties best suited

for transmission under the environmental conditions pertaining; the various treponematoses then evolved into pinta, through yaws and endemic syphilis, to venereal syphilis which has worldwide distribution today. Changes in social conditions may lead to a regression or alteration as regards the dominant treponematosis" (Willcox 1973:18). In the Old World, syphilis emerged from bejel when unhygienic habits were discarded, permitting some children to escape the childhood infection. Probably, mutations happened but they were reversible.

Will the recovery of immunoglobulin from human skeletal tissues solve the puzzle once for all? This technique allows some of the diseases to which an individual was exposed during life to be identified(Ortner et al. 1992). Considering this, Baker and Armelagos (1988) said": Newly developed immunological analysis should finally lay the controversy regarding the origin of syphilis to rest" (Baker and Armelagos 1988:720). However, I am not so optimistic. The specific anti-treponemal antibodies of the IgG class will be useful in paleopathological diagnosis. For example, Tuross and Owsley have recognized one specimen, dated to 1240 B.P., that exhibited immunological reactivity to the treponemal antigen from the Woodland culture. However, this test did not distinguish which of the treponemal syndromes was present in this individual (Ortner et al. 1992). This fact supports the

idea the treponematoses are one disease of no qualitative difference.

Based on the fact that precontact syphilitic remains are found only in the Old World, we can conclude that the Columbian hypothesis is not valid. An examination of clinical, morphological, immunological, and histological evidence proves that the treponematoses are one disease of no qualitative difference, although they are clinically distinguishable. The evolutionary model suggests that some forms of treponemal infections existed before Columbus's voyage and evolved to syphilis in the Old World when the physical and social condition selected for syphilis. On the other hand, the social conditions in the New World did not select for syphilis at all. Therefore, nonvenereal treponematosis did not evolve to venereal treponematosis in precontact times in the New World. Native Americans got syphilis from European settlers after the contact. A combination of the pre-Columbian and Unitarian hypotheses is a convincing answer to the our question. The Unitarian hypothesis explains the origin of syphilis in the Old World instead of New World and pre-Columbian hypothesis explains the emergence of syphilis in the New World.

REFERENCES CITED

Anderson, J. E. 1965. Human skeletons of Tehuacan. *Science* 148:486-97.

Armelagos, G. J. and J. R. Dewey. 1970. Evolutionary response to human infectious diseases. *BioScience* 157:638-44.

Baker, B. J. and G. J. Armelagos. 1988. The origin and antiquity of syphilis: Paleopathological diagnosis and interpretation. *Current Anthropology* 29:703-37.

Bloch, I. 1908. A system of syphilis. In *D'Arcy Power and J. Keogh Murphy.* vol. 1, 1-39. Oxford: Oxford Medical Publications.

Blondiaux, J., and A. A-L. Bagousse. 1994. Une treponematose du Bas-Empire romain en Normandie? In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G. Palfy, J. Berato, and J-P, Brun, 99-100. Toulon: Centre Archaeologique de Var.

Bogdan, G. and D. S. Weaver. 1992. Pre-Columbian treponematosis in coastal North Carolina. In *Disease and demography in the Americas,* ed. J. W. Verano and D. H. Ubelaker, 155-63. Washington, D. C.: Smithsonian.

Bradlaw, R. V. 1953. The dental stigmata of prenatal syphilis. *Oral Surgery* 6:147-58.

Brooks, S. T., R. H. Brooks, W. R. K. Perixonius. 1994. Possible syphilitic lesions: Problem cases from Holland and New Guinea. In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G. Palfy, J. Berato, and J-P, Brun, 226-32. Toulon: Centre Archaeologique de Var.

Brothwell, D. 1961. The palaeopathology of early British man: An essay on the problems of diagnosis and analysis. *Journal of the Royal Anthropological Institute* 91:318-44.

_____. 1970. The real history of syphilis. *Science Journal* 6:27-32.

_____. 1976. Further evidence of treponematosis in a pre-European population from Oceania. *Bulletin of the History of Medicine* 50:435-42.

_____. 1988. Comment. The origin and antiquity of syphilis. *Current Anthropology* 29:721

Bruhl, G. 1890. On the pre-Columbian existence of syphilis in the Western Hemisphere. *Cincinnati Lancet Clinic* 8:487-493.

Buikstra, J. E. 1979. Contribution of physical anthropologists to the concept of Hopewell: A historical perspective. In *Hopewell archaeology*, ed. D. S. Brose and N. Greber, 220-33. Kent: Kent State University Press.

Bullen, A. D. 1972. Paleoepidemiology and distribution of prehistoric treponematosis (syphilis) in Florida. *American Journal of Physical Anthropology* 25:133-74.

Butler, C. S. 1936. *Syphilis sive morbus humanus*. Lancaster Pa: Science Press.

Canale-Parola, E. 1977. Physiology and evolution of spirochetes. *Bacteriological Reviews* 41:181-204.

Canale-Parola, E., Z. Udris, and M. Mandel. 1968. The classification of free-living spirochetes. *Archives of Microbiology* 63:385-97.

Capper, A. 1925. An epitome of the history of syphilis. *Archives of Dermatology and Syphilology* 12:509-19.

Cassidy, D. M. 1980. Nutrition and health in agriculturalists and hunter-gatherers. In *Nutritional anthropology*. ed. N. W. Jerome, R. F. Kandel, and G. H. Pelto, 117-45. Pleasantville: Redgrave.

Chulay, J. D. 1995. Treponema species. In *Principles and*

practice of infectious diseases, ed. G. L. Mandell, R. G. Douglas, and J. E. Bennett. 2133-37. New York: Churchill Livingstone.

Cockburn, T. A. 1961. The origin of the treponematoses. *Bulletin of the World Health Organization* 24:221-28.

_____. 1963. *The evolution and eradication of infectious diseases. Baltimore*: John Wright.

_____. 1971. Infectious diseases in ancient populations. Current *Anthropology* 12:45-62.

Cole, H. N., J. C. Harkin. B. S. Krans., and A. R. Moritz. 1955. Pre-Columbian osseous syphilis. *Archives of Dermatology* 71:231-38.

Cook, D. C. 1976. Pathologic states and disease precess in Illinois Woodland populations: An epidemiologic approach. Ph.D. diss., University of Chicago.

_____. 1990. Epidemiology of circular caries: A perspective from prehistoric skeletons. In *A Life in Science: Papers in Honor of J. Lawrence Angel*, ed. J. E. Buikstra, 64-86. Kampsville: Center for American Archaeology.

_____. 1994. Dental evidence for congenital syphilis (and its absence)before and after the conquest of New World. In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G, Palfy, J. Berato, and J-P, Brun, 169-75. Toulon: Centre Archaeologique de Var.

Crosby, A. W., JR. 1969. The early history of syphilis: A reappraisal. *American Anthropologist* 71:218-27.

Csonka, G., and J. Pace. Endemic nonvenereal treponematosis (bejel) in Saudi Arabia. *Review of Infectious Diseases* 7:S260-65.

Dawes, J. D., and J. R. Magilton. 1980. The archaeology of York. Vol. 12, Fasc. I. *The cemetery of St. Helen-on-the-Walls, Aldwark*. York: Archaeological Trust.

Dennie, C. C. 1962. *A history of syphilis*. Springfield: Thomas

Dubos, R. 1965. *Man adapting. New Haven*: Yale University

Press.

_____. 1968. *Man, medicine, and environment.* New York: Praeger.

Eisenberg, H., F. Plotke, and A. H. Baker. 1949. Asexual syphilis in children. *Journal of Venereal Diseases Information* 30:7-11.

Elting, J. J., and W. A. Starna. 1984. A possible case of pre-Columbian treponematosis from New York State. *American Journal of Physical Anthropology* 65:267-73.

Engelhardt, H. K. 1959. A study of yaws. (Does congenital yaws occur?) Journal of Tropical Medical Hygiene 62: 238-40.

Engelkens, H. J. H., P. L. A. Niemel, J. J. Van der Sluis, A. Meheus, and E. Stolz. 1991. Endemic treponematoses. II. Pinta and endemic syphilis. *International Journal of Dermatology* 30:231-38.

Engelkens, H. J. H., V. D. Vuzevski, J. Judanarso, J. B. H. J. Van Lier, J. Van der Stek, J. J. Van der Sluis, and E. Stolz. 1990. Early yaws: A light microscopic study. *Genitourinary Medicine* 66:264-66.

Ewald, P. W. 1994, *Evolution of infectious disease.* Oxford: Oxford University Press.

Ferris, H. W., and T. B. Turner. 1937. Comparative histology of yaws and syphilis in Jamaica. *Archives of Pathology* 24:703-37.

Fournier, A. 1899. *Traite de la syphilis.* Paris: Rueff.

Fry, L., and P. Rodin. 1966. Early yaw. *British Journal of Venereal Diseases* 42:28-30.

Gladykowska-Rzeczycka, J. 1994.Syphilis in ancient and medieval Poland? In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G. Palfy, J. Berato, and J-P, Brun, 116-18. Toulon: Centre Archaeologique de Var.

Goff, C. W. 1967. Syphilis. In *Diseases in antiquity,* ed. D. Brothwell and A. T. Sandison, 279-93. Springfield: Thomas.

Green, C. A., and R. R. M. Harman. 1985. Yaws truly: A survey of patients indexed under "yaws" and a review of the clinical and laboratary problems of diagnosis. *Clinical and Experimental Dermatology* 11:41-48.

Grin, E. I. 1953. Epidemiology and control of endemic syphilis: report on a mass-treatment campaign in Bosnia. *Monograph series no. 11.* Geneva: World Health Organization.

_____. 1956. Endemic syphilis and yaws. *Bulletin of the World Health Organization* 15:959-73.

_____. 1961. Endemic treponematoses in the Sudan. *Bulletin of the World Health Organization* 24:229-38.

Guerra, F. 1978. The dispute over syphilis: Europe versus America. *Clio Medica* 13:39-61.

Hackett, C. J. 1951. *Bone lesions of yaws in Uganda*. Oxford: Blackwell Scientific Publications.

_____. 1963. On the origin of the human treponematoses. *Bulletin of the World Health organization* 29:7-41.

_____. 1967. The human treponematoses. In *Diseases in antiquity,* ed. D. Brothwell and A. T. Sandison, 279-93. Springfield: Thomas.

_____. 1976. *Diagnostic criteria of syphilis, yaws, and treponarid (treponematoses) and of some other diseases in dry bones*. Berlin: Springer-Verlag.

_____. 1983. Problems in paleopathology of the human treponematoses. In *Disease in ancient man, ed.* G. D. Hart, 106-28. Toronto: Clark Irwin.

Hamlin, H. 1939. The geography of treponematosis. *Yale Journal of Biological Medicine* 12:29-50.

Harrison, L. W. 1959. The origin of syphilis. *British Journal of Venereal Diseases* 35:1-7.

Henneberg, M., and R. J. Henneberg. 1994. Treponematosis in an ancient Greek colony of Metaponto, Southern Italy, 580-250 BCE. In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G. Palfy, J.

Berato, and J-P, Brun, 92-98. Toulon: Centre Archaeologique de Var.

Holcomb, R. C. 1934. Christopher Columbus and the American origin of syphilis. *United States Naval Medical Bulletin* 32:401-30.

_____. 1935. The antiquity of syphilis. *Medical Life* 42:275-325.

_____. 1941. The antiquity of syphilis. *Bulletin of the History of Medicine* 10:148-77.

Hollander, D. C. 1981. Treponematosis from pinta to venereal syphilis revisited: Hypothesis for temperature determination of disease patterns. *Sexually Transmitted Diseases* 8:34-37.

Holmes, L. D., and W. Parris. 1981. *Anthropology: An introduction*. New York: John Wiley & Sons.

Holt, S. C. 1978. Anatomy and chemistry of spirochetes. *Microbiology Reviews* 42:114-60.

Hooton, E. A. 1930. *The Indians of Pecos Pueblo*. New Haven: Yale University Press.

Hovind-Hougen, K. 1983. Morphology. In *Pathogenesis and immunology of treponemal infection*. Immunology Series no. 20, ed. R. F. Schell, and D. M. Musher, 3-28. New York: Marcel Dekker.

Hudson, E. H. 1946. *Treponematosis*. Oxford: Oxford University Press.

_____. 1958. *Non-venereal syphilis: A sociological and medical study of bejel*. Edinburgh: E. and S. Livington.

_____. 1961. Historical approach to the terminology of syphilis. *Archives of Dermatology* 84:545-62.

_____. 1963a. Treponematosis and anthropology. *Annals of International Medicine* 58:1037-49.

_____. 1963b. Treponematosis and pilgrimage. *American Journal of Medical Sciences* 246:645-56.

_____. 1964. Treponematosis and African slavery. *British Journal of Venereal Diseases* 48:145-53.

_____. 1965a. Treponematosis and man's social evolution. *American Anthropologist* 67:885-901.

_____. 1965b. Treponematosis in perspective. *Bulletin of the World Health Organization* 32:735-48.

_____. 1972. Diagnosing a case of venereal disease in fifteenth century Scotland. *British Journal of Venereal Diseases* 48:146-53.

Hunt, D., and A. L. Johnson. 1923. Yaws, a study based on over 2,000 cases treated in American Samoa. *US Navy Medical Bulletin* 18:599-607.

Hutchinson, D. L. 1993. Treponematosis in regional and chronological perspective from central gulf coast Florida. *American Journal of Physical Anthropology* 92:249-61.

Hutchinson, J. 1863. *Journal of a clinical memoir on certain diseases of the eye and ear consequent on inherited syphilis*. London: Churchill.

Hyde, J. N. 1891. A contribution to the study of pre-Columbian syphilis in America. *American Journal of Medical Sciences* 102:117-31.

Inhorn, M. C. and P. J. Brown. 1990. The anthropology of infectious disease. *Annual Reviews of Anthropology* 19:89-117.

Jacobi, K. P., C. D. Cook, R. S. Corruccini, and J. S. Handler. 1992. Congenital syphilis in the past: Slaves at Newton Plantation, Barbados, West Indies. *American Journal of Physical Anthropology* 89:145-58.

Jaffe, H. L. 1972. *Metabolic, degenerative and inflammatory diseases of bone and joints*. Philadelphia: Lea& Febiger.

Jones, J. 1876. Explorations of the aboriginal remains of Tennessee. *Smithsonian Contributions to Knowledge* 22:1-171.

Kennedy, K. A. R. 1990. Reconstruction of trauma, disease and life ways of prehistoric people of southeast Asia from skeletal records. In *South Asian archaeology*, ed. M. Z. Taddi 61-77. International Conference Association.

Kerley, E. R.,and W. M. Bass. 1967. Paleopathology: Meeting ground for many disciplines. *Science* 157:638-44.

Koff, A. B. and T. Rosen. 1993. Nonvenereal treponematoses: Yaws, endemic syphilis, and pinta. *Journal of the American Academy of Dermatology* 29:519-35.

Lamb, D. S. 1898. Pre-Columbian syphilis. *Proceedings of the Association of American Anatomists* 10:63-69.

Luger, A. 1972. Non-venereally transmitted 'endemic' syphilis in Vienna. *British Journal of Venereal Diseases* 48:356-60.

Maccurdy, G. G. 1923. Human skeletal remains from the highlands of Peru. *American Journal of Physical Anthropology* 6:217-329.

Madrid, A. 1986. Work in historical osteology at the National Museum of Antiquities in Sweden. *Museum* 38:155-57.

Mansilla, J., and C. Pijoan. 1994. Treponematosis in Mexico. In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G. Palfy, J. Berato, and J-P, Brun, 185-190. Toulon: Centre Archaeologique de Var.

Marcsik, A. 1994. Data to the epidemiology of syphilis in ancient population in Central Europe. In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G. Palfy, J. Berato, and J-P, Brun, 233-36. Toulon: Centre Archaeologique de Var.

Miao, R. M., and Fieldsteel A. H. 1980. Genetic relationship between *Treponema pallidum* and *Treponema pertenue*, Two non-cultivable human pathogens. *Journal of Bacteriology* 141:427-29.

Mohamed, K. N. 1990. Late yaws and optic atrophy. *Annals of Tropical Medicine and Parasitology* 84:637-39.

Morant, G. M., and M. G. Hoadley. 1931. A study of the

recently excavated Spitalfields crania. *Biometrika* 23:191-248.

Morse, K. 1967. Two cases of possible treponema infection in prehistoric America. In *Miscellaneous papers in paleopathology*, Vol. I. ed. W. D. Wade, 48-60. Museum of Northern Arizona, Technical Series no. 7.

Mckeown, T. 1988. *The origins of human disease*. Oxford: Blackwell.

Morton, R. S. 1967. The sibbens of Scotland. *Medical History* II:374-80.

Naranjo, P. 1995. On the American Indian origin of syphilis: Fallacies and errors. In *Columbus and the New World: Medical implications*, ed. G. A. Settipane, 33-43. Rhode Island: Ocean Side Publications.

Niemel, P. L. A., E. A. Brunings, and H. E. Menke. 1979. Attenuated yaws in Surinam. *British Journal of Venereal Diseases* 55:99-101

Noguchi, H. 1928. *The spirochete*. Chicago: The University of Chicago Press.

Noordhoek, G. T., A. Cockayne, L. M. Schouls, R. H. Meloen, E. Stolz, and J. D. A. Van Embden. 1990. A new attempt to distinguish serologically the subspecies of *Treponema pallidum* causing syphilis and yaws. *Journal of Clinical Microbiology* 28:1600-07.

Noordhoek, G. T., B. Wieles, J. J. Van der Sluis, and J. D. A. Van Embden. 1990. Polymerase chain reaction and synthetic DNA probes: A means of distinguishing the causative agents of syphilis and yaws? *Infection and Immunology* 58:2011-13.

Noordhoek, G. T., P. W. M. Hermans, A. N. Paul, L. M. Schouls, J. J. van der Sluis, and J. D. A. Van Embden. 1989. *Treponema pallidum* (Nichols) subspecies *pallidum* and *Treponema pallidum* subspecies *pertenue* (CDC2575) differ in at least one nucleotide: comparison of two homologous antigens. *Microbiological Pathology* 6:29-42.

Orton, S. Y. 1905. A study of the pathological changes in some mounddwellers' bones from the Ohio Valley with especial reference to syphilis. *University of*

Pennsylvania Medical Bulletin 18:36-44.

Ortner, K. J., and W. G. J. Putschar. 1985. Reprinted edition. *Identification of pathological conditions in human skeletal remains.* Washington, D. C.: Smithsonian Institution Press.

Ortner, D. J., N. Tuross, and A. I. Stix. 1992. New approaches to the study of disease in archaeological New World populations. *Human Biology* 64:337-60.

Pace, J. L. 1983. Treponematoses in Arabia. *Saudi Medical Journal* 4:211-20.

Pace, J. L., and G. W. Csonka. 1984. Endemic non-venereal syphilis (bejel) in Saudi Arabia. *British Journal of Venereal Diseases* 60:293-97.

Palfi, G. Y., O. Dutour, J.P. Brun, and J. Brerato. 1992. Pre-Columbian congenital syphilis from late antiquity in France. *International Journal of Osteoarchaeology* 2:245-61.

Pietrusewsky, M. 1971. An osteological study of cranial and infracranial remains from Tonga. *Records of the Auckland Institute and Museum* 6:287-402.

Polgar, S. 1964. Evolution and the ills of mankind. *In Horizons of anthropology,* ed. S. Tax, 200-11. Chicago: Aldine.

Powell, M. L. 1988. On the eve of the conquest: Life and death at Irene Mound, Georgia. In *Postcontact biocultural adaptation of Native American populations on St. Catharines Island, Georgia,* ed. D. H. Thomas. and C. S. Larsen, New York: American Museum of Natural History.

_____. 1994. Why call it syphilis? In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G. Palfy, J. Berato, and J-P, Brun, 158-63. Toulon: Centre Archaeologique de Var.

Power, C. 1992. The spread of syphilis and a possible early case in Waterford. *Archaeology* (Ireland) 6:20-21.

Pusey, W. A. 1933. *The history and epidemiology of syphilis*

Springfield: Thomas.

Rao, V. V., T. S. Vasulu, and A. D. W. Rector Babu. 1996. Possible paleopathological evidence of treponematosis from a Megelithic site at Argipalle, India. *American Journal of Physical Anthropology 100:49-55.*

Rabkin, S. 1942. Dental conditions among Prehistoric Indians of Northern Alabama. *Journal of Dental Research* 21:211-22.

Reichs, K. J. 1989. Treponematosis: A possible case from the Late Prehistoric of North Carolina. *American Journal Physical Anthropology* 79:289-303.

Roberts, C. 1993. Pre-Columbian syphilis in England in a well-Preserved adult female skeleton from Gloucester. *Journal of Paleopathology* 5:III.

_____. 1994. Treponematosis in Gloucester (England): Theoretical and practical approach to the pre-Columbian theory. In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G, Palfy, J. Berato, and J-P, Brun, 101-08. Toulon: Centre Archaeologique de Var.

Rokhlin, D. G. 1965. *Diseases of ancient men: Bones of the men of various epochs, normal and pathological changes.* Moscow-Leningrad: Nauka.

Roman, G. C., and L. N. Roman. 1986. Occurrence of congenital, cardiovascular, visceral, neurologic, and neuro-ophthalmologic complications in late yaws: A theme for future research. *Reviews of Infectious Diseases* 8:760-70.

Roney, J. G., JR. 1966. Palaeoepidemiology: An example from California. In *Human palaeopathology,* ed. S. Jarcho, 99-107. New Haven: Yale University Press.

Rothschild, M., and T. Clay. 1952. *Fleas, flukes, and cuckoos.* New York: Philosophical Library.

Saul, F. P. 1972. *The Human skeletal remains of altar de sacrificios.* Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University.

Shattuck, G. C. 1938. Lesions of syphilis in American Indians. *American Journal of Tropical Medicine* 18:577-

86.

Smibert, R. M. 1984. Genus III. Treponema Schaudinn 1905, 1728, In *Bergey's manual of systematic bacteriology,* Vol. 1. ed. N. R. Krieg and J. G. Holt, 49-57. Baltimore: The Willims & Wilkins

Smith, J. L. 1971. Neuro-ophthalmological study of late yaws. I. An introduction to yaws. *British Journal of Venereal Diseases* 47:223-5.

Smith, T., 1934. *Parasitism and disease.* Princeton: Princeton University Press.

Snow, C. E. 1962. *Indian Burials from St. Petersburg, Florida. Contributions of the Florida State Museum, social sciences.* No. 8. Gainesville.

Steinbock, R. T. 1976. *Paleopathological diagnosis and interpretation.* Springfield: Thomas.

Steyn, M., and Henneberg M. 1995. Pre-Columbian presence of treponemal disease: A possible case from Iron Age Southern Africa. *Current Anthropology* 36:869-73.

Stewart, T. D., and A. Spoehr. 1952. Evidence of the paleopathology of yaws. Bulletin of the History of Medicine 26:538-53.

_____. 1967. Evidence on the palaeopathology of yaws. In *Diseases in antiquity,* ed. D. Brothwell and A. T. Sandison, 307-19. Springfield: Thomas.

Stirland, A. 1991. A pre-Columbian treponematosis in medieval Britain. *International Journal of Osteoarcheology* 1:39-47.

_____. 1994. Evidence for pre-Columbian treponematosis in medieval Europe(England). In *The origin of syphilis in Europe: Before and after 1493?* ed. O. Dutour, G. Palfy, J. Berato, and J-P, Brun, 109-15. Toulon: Centre Archaeologique de Var.

Tramont, E. C. 1995. *Treponema pallidum.* In *Principles and practice of infectious diseases,* ed. G. L. Mandell, R. G. Douglas, and J. E. Bennett. 2117-33. New York: Churchill Livingstone.

Turner, T. B., and D. H. Hollander. 1957. Biology of the treponematoses. *Monograph series no. 35*. Geneva: World Health Organization.

Vasulu, T. S. 1993. The origin and antiquity of syphilis (Treponematosis) in southeast Asia. *Human Evolution*. 8:229-33.

Veldkamp, H. 1960. Isolation and characteristics of *Treponema zuelzerae* now, spec., An anaerobic, free-living spirochete, Antonie van Leeuwenhoek, *Journal of Microbiology and Serology* 26:103-25.

Virchow, R. 1858. Ueber die Natur der constitutionell-syphilitischen Affectionenem. *Virchows' Archives of Pathological and Anatonical Physiology* 15:217-336.

_____. 1896. Beitrage zur geschichte der lues. Derm. Z. 3:1-9.

Vorst, F. A. 1985. Clinical diagnosis and changing manifestations of treponemal infection. *Reviews of Infectious Disease* 7:S327-31.

Walker, E. G. 1983. Evidence for prehistoric cardiovascular diseases of syphilitic origin on the Northern Plains. *American Journal of Physical Anthropology* 60:499-503.

Weisman, A. I. 1966. Syphilis: Was it endemic in pre-Columbian America or was it brought here from Europe? *Bulletin of New York Academy of Medicine* 42:284-300.

Wicher, K. 1983. Pathology of treponematosis. In *Pathogenesis and immunology of treponemal infection*, ed. R. F. Schell and D. M. Musher, 55-67. New York: Marcel Dekker.

Williams, H. U. 1927. American origin of syphilis, with citations from early Spanish authors collected by Dr. Montejo y Robledo. *Archives of Dermatology and Syphilis* 16:683-696.

_____. 1929. Human paleopathology with some original observations on symmetrical osteoporosis of the skull. *Archives of Pathology* 7:839-902.

_____. 1932. The origin and antiquity of syphilis: the evidence from diseased bones, a review, with the new

material from America. *Archives of Pathology* 13:799-814,931-83.

_____. 1936. The origin of syphilis: Evidence from diseased bones, a supplementary report. *Archives of Dermatology and Syphilology* 33:783-87.

Willcox, R. R. 1973. The treponemal evolution. In *Sexually transmitted diseases*, ed. L. Nicholas, 3-25. Springfield: Charles Thomas.

_____. 1974. Changing patterns of treponemal disease. *British Journal of Venereal Diseases* 50:169-78.

Wilson, P. W. 1934. Atypical yaws. *American Journal of Tropical Medicine* 14:1-25.

Zhang, Z. 1994. The skeletal evidence of human leprosy and syphilis in ancient China. *Acta Anthropologica Sinica* 13:294-99.

Zinsser, H. 1935. *Rats, lice and history*. Boston: Little Brown.